

The 18th World Multi-Conference on Systemics, Cybernetics and Informatics

July 15 - 18, 2014 - Orlando, Florida, USA

PROCEEDINGS

Volume II

Post-Conference Edition

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Organized by International Institute of Informatics and Systemics Member of the International Federation for Systems Research (IFSR)

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ISBN: 978-1-941763-03-2 (Collection)

ISBN: 978-1-941763-10-0 (Volume II)



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Country	# Papers	%
TOTAL	116	100.00
United States	26	22.41
Japan	13	11.21
Czech Republic	9	7.76
Latvia	9	7.76
Brazil	5	4.31
Lithuania	5	4.31
Taiwan	5	4.31
Slovakia	4	3.45
India	3	2.59
Israel	3	2.59
Russian Federation	3	2.59
South Africa	3	2.59
South Korea	3	2.59
Turkey	3	2.59
Canada	2	1.72
China	2	1.72
Italy	2	1.72
Lebanon	2	1.72
Thailand	2	1.72
Venezuela	2	1.72
Chile	1	0.86
Ecuador	1	0.86
Finland	1	0.86
Germany	1	0.86
Iran	1	0.86
Malaysia	1	0.86
Mexico	1	0.86
Sweden	1	0.86
United Kingdom	1	0.86
Vietnam	1	0.86
Foreword

Our purpose in the 18th World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI 2014) is to provide, in these increasingly related areas, a multi-disciplinary forum, to foster interdisciplinary communication among the participants, and to support the sharing process of diverse perspectives of the same transdisciplinary concepts and principles.

Systemics, Cybernetics and Informatics (SCI) are being increasingly related to each other in almost every scientific discipline and human activity. Their common transdisciplinarity characterizes and communicates them, generating strong relations among them and with other disciplines. They work together to create a whole new way of thinking and practice. This phenomenon persuaded the Organizing Committee to structure WMSCI 2014 as a multi-conference where participants may focus on one area, or on one discipline, while allowing them the possibility of attending conferences from other areas or disciplines. This systemic approach stimulates cross-fertilization among different disciplines, inspiring scholars, originating new hypothesis, supporting production of innovations and generating analogies; which is, after all, one of the very basic principles of the systems' movement and a fundamental aim in cybernetics.

WMSCI 2014 was organized and sponsored by the International Institute of Informatics and Systemics (IIIS, www.iiis.org), member of the International Federation of Systems Research (IFSR). The IIIS is a *multi-disciplinary organization for inter-disciplinary communication and integration*, which includes about 4500 members. Consequently, a main purpose of the IIIS is to foster knowledge integration processes, interdisciplinary communication, and integration of academic activities. Based on 1) the transdisciplinarity of the systemic approach, along with its essential characteristic of emphasizing *relationships* and *integrating* processes, and 2) the multi-disciplinary support of cybernetics' and informatics' concepts, notions, theories, technologies, and tools, the IIIS has been organizing multi-disciplinary conferences as a platform for fostering inter-disciplinary communication and knowledge integration processes.

Multi-disciplinary conferences are organized by the IIIS as support for both intra- and inter-disciplinary communication. Processes of intra-disciplinary communication are mainly achieved via traditional paper presentations in corresponding disciplines, while conversational sessions, regarding trans- and inter-disciplinary topics, are among the means used for intercommunication. Intra- and inter-disciplinary disciplinary communications might generate co-regulative cybernetic loops, via negative feedback, and synergic relationships, via positive feedback loops, in which both kinds of communications could increase their respective effectiveness. Figure 1 shows at least two cybernetic loops if intra- and inter-disciplinary are adequately related. A necessary condition for the effectiveness of Inter-disciplinary communication is an adequate level of variety regarding the participating disciplines. Analogical thinking and learning processes of disciplinarians depend on it; which in turn are potential sources of the creative tension required for crossfertilization among disciplines and the generations of new hypothesis. An extended presentation regarding this issue can be found at www.iiis.org/MainPupose.



Figure 1

In the specific case of Systemics, Cybernetics and Informatics (SCI), the IIIS is an organization dedicated to contribute to the development of the Systems Approach, Cybernetics, and Informatics potential, using both: knowledge and experience, thinking and action, theory and practice, for:

- a) the identification of synergetic relationships among Systemics, Cybernetics and Informatics, and between them and society;
- b) the promotion of contacts among the different academic areas, through the transdisciplinarity of the systems approach;
- c) the identification and implementation of communication channels among the different professions;
- d) the supply of communication links between the academic and professional worlds, as well as between them and the business world, both public and private, political and cultural;
- e) the stimulus for the creation of integrative arrangements at different levels of society, as well as at the family and personal levels;
- f) the promotion of transdisciplinary research, both on theoretical issues and on applications to concrete problems.

These IIIS objectives have directed the organizational efforts of yearly WMSCI/ISAS conferences since 1995.

On behalf of the Organizing Committee, I extend our heartfelt thanks to:

- 1. the 746 members of the Program Committee from 59 countries (including the PC members of the events organized in its context and jointly with it);
- 2. the 503 additional reviewers, from 64 countries, for their **double-blind peer reviews**; and
- 3. the 175 reviewers, from 42 countries, for their efforts in making the **non-blind peer reviews**. (Some reviewers supported both: non-blind and double-blind reviewing for different submissions).

A total of 1052 reviews made by 678 reviewers (who made at least one review) contributed to the quality achieved in WMSCI 2014. This means an average of 6.30 reviews per submission (167 submissions were received). *Each registered author had access, via the conference web site, to the reviews that recommended the acceptance of their respective submissions*. Each registered author could also get information about: 1) the average of the reviewers evaluations according to 8 criteria, and the average of a global evaluation of his/her submission; and 2) the comments and the constructive feedback made by the reviewers, who recommended the acceptance of his/her submission, so the author would be able to improve the final version of the paper.

In the organizational process of WMSCI 2014, about 167 papers/abstracts were submitted. These post-conference proceedings include about 116 papers that were accepted for presentation from 30 countries (45 countries taking into account the presentations in collocated events). I extend our thanks to the invited sessions' organizers for collecting, reviewing, and selecting the papers that will be presented in their respective sessions. The submissions were reviewed as carefully as time permitted; it is expected that most of them will appear in a more polished and complete form in scientific journals.

This information about WMSCI 2014 is summarized in the following table, along with the other collocated conferences:

Conference	# of submissions received	# of reviewers that made at least one review	# of reviews made	Average of reviews per reviewer	Average of reviews per submission	# of papers included in the proceedings	% of submissions included in the proceedings
WMSCI 2014	167	678	1052	1.55	6.30	116	69.46%
IMSCI 2014	90	324	580	1.79	6.44	48	53.33%
IMETI 2014	61	306	605	1.98	9.92	27	44.26%
CISCI 2014	120	518	1166	2.25	9.72	56	46.67%
TOTAL	438	1826	3403	1.86	7.77	247	56.39%

We also extend our gratitude to the invited sessions and special track organizers, as well as to the coeditors of these proceedings, for the hard work, energy and eagerness they displayed preparing their respective sessions. We express our intense gratitude to Professor William Lesso for his wise and opportune tutoring, for his eternal energy, integrity, and continuous support and advice, as the Program Committee Chair of past conferences, and as Honorary President of WMSCI 2014, as well as for being a very caring old friend and intellectual father to many of us. We also extend our gratitude to Professor Belkis Sánchez, who brilliantly managed the organizing process.

Our gratitude to Professors Bela H. Banathy, Stafford Beer, George Klir, Karl Pribram, Paul A. Jensen, and Gheorghe Benga who dignified our past WMSCI conferences by being their Honorary Presidents. Special thanks to Dr. C. Dale Zinn and Professor Jorge Baralt for co-chairing WMSCI 2014 Program Committee and to professors Andrés Tremante and Belkis Sánchez for co-chairing the Organizing Committee. We also extend our gratitude to the following scholars, researchers, and professionals who accepted to deliver plenary workshops and/or to address the audience of the General Joint Plenary Sessions with keynote conferences.

<u>*Plenary Workshop*</u>, more details (abstracts and short bios) were included in the Conference Program booklet and at http://www.iiis.org/summer2014plenaryevents/

Professor Thomas Marlowe, Seton Hall University, USA, Department of Mathematics and Computer Science, Program Advisor for Computer Science, Doctor in Computer Science and Doctor in Mathematics

Dr. Susu Nousala, Aalto University, Finland, Researcher in Sustainable Design, and Research Fellow at the (Australasian Centre for the Governance and Management of Urban Transport) Faculty of Architecture- Buildi

<u>Plenary Keynote Speakers</u>, more details more details (abstracts and short bios) were included in the Conference Program booklet and at http://www.iiis.org/summer2014plenaryevents/

Professor Leonid Perlovsky, Harvard University and The Air Force Research Laboratory, USA

Professor Shigehiro Hashimoto, Kogakuin University, Japan, Associate to the President and Dean of Admissions Center, Doctor of Engineering and Doctor of Medicine Biomedical Engineering

Professor T. Grandon Gill, University of South Florida, USA, Director of the Doctorate of Business Administration

Dr. Jeremy Horne, President-emeritus, Southwest Area Division, American Association for the Advancement of Science (AAAS), USA

Dr. Karl H. Müller, Director of The Steinbeis Transfer Center New Cybernetics, Vienna, Austria and Professor at the University of Ljubljana, Slovenia

Professor Richard Segall, Arkansas State University, USA, Computer Information Technology

Professor Thomas Marlowe, Seton Hall University, USA, Department of Mathematics and Computer Science, Program Advisor for Computer Science, Doctor in Computer Science and Doctor in Mathematics

Dr. Ronald Styron, University of South Alabama, USA, Director of the Quality Enhancement Plan

Dr. Heidi Ann Hahn, Los Alamos National Laboratory, USA, Director of the Engineering Capability Development, Past President of the International Council of Systems Engineering (INCOSE) Enchantment Chapter

Dr. Robert Cherinka, MITRE Corporation, USA, Senior Principal Information Systems Engineer

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Professor Sallyanne Payton, University of Michigan, USA, William W. Cook Professor of Law Emeritus, Professor of Art and Design Emerita University of Michigan Law School- Project Director

Many thanks to Drs. Dale Zinn, Sushil Archarya, Esther Zaretsky and professors Michael Savoie, Jorge Baralt, Hsing-Wei Chu, Mohammad Siddique, Andrés Tremante, Friedrich Welsch, Thierry Lefevre, José Vicente Carrasquero, Angel Oropeza, and Freddy Malpica for chairing and supporting the organization of conferences and/or special tracks in the context of, or collocated with, WMSCI 2014. We also wish to thank all the authors for the quality of their papers, and the Program Committee members and the additional reviewers for their time and their contributions in the respective reviewing processes.

We extend our gratitude as well to María Sánchez, Juan Manuel Pineda, Leonisol Callaos, Dalia Sánchez, Keyla Guédez, Marcela Briceño, and Freddy Callaos for their knowledgeable effort in supporting the organizational process producing the hard copy and CD versions of the proceedings, developing and maintaining the software supporting the interactions of the authors with the reviewing process and the Organizing Committee, as well as for their support in the help desk and in the promotional process.

Professor Nagib C. Callaos, Ph. D. WMSCI 2014 General Chair www.iiis.org/Nagib-Callaos

WMSCI 2014

The 18th World Multi-Conference on Systemics, Cybernetics and Informatics Special Track on Bio- and Medical Informatics and Cybernetics: BMIC 2014 Special Track on Management, Engineering and Informatics: MEI 2014 Special Track on Risk Management and Cyber-Informatics: RMCI 2014 Special Track on Knowledge and Cognitive Science and Technologies: KCST 2014

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Sustainable Energy Sector Strategy in the Context of Universal Country Sustainability

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ABSTRACT

Sustainable development of country energy sector is closely related with country universally sustainable development. These relations are met in national as well as in regional laws and in legal documents regulating their implementation. However, the problem remains as follows: how the key provisions of universally sustainable development are integrated into the development strategies of energy companies and how they are applied while implementing strategic investment projects. Thus the paper aims to reveal the theoretical and practical content of country energy system development sustainability, as well as systemically assess possibilities, means and the role of government in preparing and implementing universally sustainable integrated development strategies for the energy sector and energy companies of a medium size country. The paper analyses assumptions of country energy system sustainability, the strategies of energy sector and their proposed instruments, as well as implementation statistics. Sustainable energy sector development is investigated by the example of Lithuania as a medium size country.

Keywords: Energy Sector, Universally Sustainable Development, Sustainability of Energy System, Renewable Energy Sources, Energy Security.

1. INTRODUCTION

In today's globally driven universal country and energy industry sustainability, it is no longer possible for an energy company to focus solely on deriving value only for its shareholders. In the same time, sustainable energy policy cannot be efficiently developed on a national level [2]. In European Union the solutions made by one Member State on energy policy inevitably impact other Member States, as well as the whole market of the region. Only the market bigger than a continent could be suitable for determining the proper match of energy types and for developing renewable sources of energy. Energy sector is a specific market sector that can achieve the highest economic efficiency through global actions.

The Law on Energy of the Republic of Lithuania [6] presents overall objectives of the energy activity, "...sustainable including the following: development of energy sector, reduction of negative impact of energy activity on environment, creation and fostering of conditions for efficient competition in energy sector, development of the use of local and renewable energy sources". However, the problem remains: how these key provisions of universally sustainable development are included development strategies of energy into the companies, and, the most important, how they are applied in the implementation practice of strategic investment projects.

The objective of the paper can be defined as follows: considering provisions of economic theory and with regard to the concept of universally sustainable development, to reveal the contemporary theoretical and practical content of medium size country energy system development sustainability. In order to reach this objective, the following tasks have been formulated:

- to reveal the conception of energy sector sustainability, to analyse its components and influencing factors;
- to analyse Lithuanian energy sector and related strategies intended to foster the universally sustainable development; also, to evaluate the current state of the country energy system in the context of sustainable energy sector development;
- to analyse systemically the possibilities, instruments and the role and effectiveness of government actions in preparing and implementing universally sustainable integrated development strategies of the energy sector and energy companies of a medium size country under conditions of globalization.

2. ASSUMPTIONS AND COMPONENTS OF COUNTRY ENERGY SYSTEM SUSTAINABILITY

Sustainability of country energy system can be defined as current and future potential of a technological energy system that ensures a longterm reliable supply of energy and energy resources formed on the basis of innovations for the national business, public sector and citizens under conditions of active competitive market. The country policy of sustainable energy should be coordinated with objectives of supply reliability, competitiveness and environmental sustainability [5].

It is possible to measure the energy system sustainability using the indicators of the first and second level.

First level indicators:

- overall level of energy resources consumption;
- energy independence;
- the ratios of energy sustainability index provided by the World Energy Council [15].

Second level indicators:

- the use of renewable energy sources;
- the amount of greenhouse gas emissions;

- electricity produced using renewable sources;
- transport energy consumption to GDP ratio;
- electricity produced using combined cycle method;
- efficiency of energy production and consumption;
- applied and planned taxes for the energy resources.

The intelligence of country technological energy system is the ability to foresee how the utility of energy resources and energy provision services results in a monetary expression and how time, uncertainty and globalization changes this value. The provided concept can be supplemented with a perception how to manage the creation of innovative wealth in order for the country to remain competitive and innovative with regard to energy production and consumption.

Technological energy intelligence can be reached using following means:

- to prepare and implement the energy policy coordinated with sustainable development objectives;
- to include the energy efficiency into the general policy of the country by coordinating actions of the sectors and by creating and implementing the respective regulation;
- to implement applied scientific research works, information and education activities in the fields of efficient energy consumption and use of renewable and waste energy sources.

Overall sustainability of country energy system is impossible without the adequate consideration of country energy problems and the perception of energy system sustainability demand by the individual subjects of society - energy business companies and the consumers of their provided services. Energy companies should foster management intelligence, based on value creation chain knowledge and experience, as well as on adequate management system. It is worth recalling that a business management system is a set of management structural elements, decisions and means intended towards the change of current situation into the preferable state using feedback channels and related processes. The system can contain human resources, organizational structures, methodologically-grounded ways, methods and procedures that are linked together to ensure efficiency of business solutions [16]. Thus an adequate management system is equally important

in fostering management intelligence in energy sector as through its ways, methods and procedures it can allow increasing the efficiency of energy resources and energy consumption, and the use of renewable energy resources in all the sectors of economy.

Many governments and societies at large have begun a robust campaign to ensure that companies using natural resources are addressing long-term issues and have a clear and articulated strategy to be both profitable and universal sustainable at the same time. The only way in which energy companies can achieve this is to first gain the trust of their key stakeholders. Whether these be governments, investors, regulators, employees, NGOs, or others, it is fundamental that their operations are conducted in responsible and sustainable way. Energy a companies are increasingly facing broad requirements under which they are expected to identify and respond to stakeholder and societal needs.

And, finally, the innovative energy intelligence of society can be defined as knowledge and abilities how to adapt to the changes of external environment and use its own potential more efficiently in order to cover and implement the sustainable development provisions on all levels and implement the transformations ensuring sustainable development. The function of individual subjects of society (users) – to form the intelligent resources and use rationally and efficiently the energy resources – requires substantial responsibility and intelligence.

3. SUSTAINABLE STRATEGIES IN ENERGY SECTOR AND THEIR INSTRUMENTS

According to the World Energy Council [15], Lithuania is on 31st place among 94 world countries in energy sustainability ranking. Lithuanian Sustainable Development Strategy (SDS) is the main policy document describing the priorities of Lithuanian environmental policies and tools for the implementation of targets set by strategy [12].

The Committee from representatives of all relevant Ministries for the preparation of biennial reports on the implementation of sustainable development strategy and the submission to Sustainable Development Commission chaired by Prime Minister was established on 28 July 2000 by the Governmental resolution. The Biannual Report on implementation of Lithuanian SDS was prepared by group of experts and was evaluated on 2005 and amendments for SDS were prepared in 2006. The Second Biannual Report was prepared in 2007 and analysis of sustainable development indicators was performed for 2002–2006. The sustainable development indicators set established in Lithuanian SDS for monitoring progress towards implementation of SDS goals.

Economic indicators: gross domestic product (GDP), final energy consumption, share of biofuels in transport fuels, share of renewables in electricity production.

Environmental indicators: urban air quality, groundwater quality, amount of households waste.

Social indicators: employment rate, poverty rate, life expectancy, etc.

Regional development indicators: GDP per capita and its ratio to national average, foreign investments and its ratio to national average, etc.

Eco-effectiveness indicators for indication of decoupling: energy and resource consumption per GDP, emission of pollutants per unit of TPES and unit of GDP.

The list of indicators is being published annually by State Department of Statistics to monitor progress of implementation of Lithuanian SDS since 2004. The best result in Lithuania based on biannual reports is achieved in development of eco-efficiency indicators.

The GDP growth rates since 2000 exceed the final energy growth rates and final energy consumption growth rates exceeds the pollution growth rate. Therefore the main conclusion from Biannual Report on implementation of sustainable development strategy is that Lithuania has reached the path of sustainable development then decoupling of resource consumption from economic growth and decoupling of pollution from resource consumption is achieved however the main challenges for implementation of sustainable development in Lithuania are related with social dimension of sustainability. The main social indicators of welfare (inequality of income, average life-time expectancy, poverty, etc.) set for monitoring of implementation of SDS of Lithuania are not decoupling from economic growth. Some of them even exhibit negative trends.

Other strategies (National Energy Independence Strategy, National Energy Efficiency Programme, Programme for the Promotion of the Production and Use of Biofuel in 2004–2010 [10, 11, 13]) also include the eco-efficiency indicators mentioned above. These eco-efficiency indicators in energy sector can be used for monitoring progress towards sustainable energy development in Lithuania and for the comparison of results achieved by other Baltic States.

4. LITHUANIAN ENERGY SECTOR: CURRENT SITUATION AND PERSPECTIVES

The highest level of energy consumption during the independent life of Lithuania was achieved in 2008. According to the information provided by the Lithuanian Energy Institute (LEI) [7] in the mentioned year Lithuanian final energy consumers used 57 TWh of energy. The biggest yearly amount of final energy was used for the production of heat – about 26 TWh, or 46 percent of all energy amount used in Lithuania. The overall consumption of electricity in the decade of growing economy also experienced a steady growth for about 0.4 TWh per year, so in 2020 Lithuania should consume about 13 TWh of electricity.

Further the energy production data of Lithuania will be presented.

	2009	2010	2011	2012
Crude Oil	117.5	117.3	116.9	104.6
Peat	14.7	8.7	11.7	16.9
Nuclear	2828.2	-	-	-
Energy				
Hydro Energy	36.5	46.4	41.3	36.3
Firewood and	1003.2	1002.9	984.0	992.7
Waste				
Biogas and	113.0	114.1	95.2	121.6
Liquid Biofuel				
Energy from	214.6	209.4	244.3	235.9
Chemical				
Processes				
Other Energy	18.7	23.8	44.1	50.5
Sources				
Total	4346.3	1522.7	1537.5	1558.5

Table 1. Energy production balances, 2009-2012, ktoe [9]

Even if Lithuanian industry sector consumes only about 20 percent of all final energy (in 2012 – 19.9%), often the possibilities of energy consumption efficiency increase are related with structural and technological changes in industry.

As it can be seen from Fig. 1, in 2012 the biggest part of final energy was consumed by the four industry sectors especially important for the national economy: chemistry and chemical products

production (33%), non-metal mineral products production (19.1%), food, drink and tobacco production (20.4%) and wood, paper and paper products production (14.4%). According to the consumed electricity, the industry sectors are distributed more equally, but the companies of the four mentioned industry sectors have used 77.2% of overall electricity consumed in industry.



Fig. 1. The structure (%) of final energy consumption in industry sectors, 2012 [14]

In recent years the progress has been achieved by the broad use of renewable energy sources: in 2012 the share of these resources in the overall primary energy balance of the country has increased to 15.8% and in overall final energy expenses to 21.6% [8].

The energy consumption efficiency improved substantially. To produce a unit of GDP, in 2012 the primary energy accounted for 64.4% less than in 2000. However, in order to reach the EU average according this ratio, Lithuania should increase its energy consumption efficiency to almost 20%.

Currently the energy produced using renewable resources is more expensive compared to traditional energy sources. In other words, relative initial investment into the technologies of renewable energy sources is bigger than the investment into traditional fossil fuels technologies. Thus in order to promote the use of renewable energy sources for energy production, on the first step the government support or the shift of highest costs on consumers will be required [1].

Table 2. Share of renewable energy in gross final energy consumption, % [4]

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Target
EU 28	8.3	8.7	9.3	10.0	10.5	11.9	12.5	12.9	14.1	20
Lithuania	17.2	17.0	17.0	16.7	18.0	20.0	19.8	20.2	21.7	23

5. ENERGY SECURITY AS IMPORTANT CONDITION OF SUSTAINABLE ENERGY STRATEGY

Sustainable energy sector strategy in the context of universal country sustainability is strongly related with ensuring the energy security. Energy security is a component part of the national security and requires a predictable, reliable, economically acceptable and environmentally friendly supply of energy. Energy security covers a whole of conditions ensuring a variety of traditional and renewable primary energy sources, a variety of energy supply channels and reliability as well as independence of the monopolistic suppliers, also the accessibility of energy for the final user under reasonable prices in a competitive energy market. Lithuania relates its energy security with the integration of national energy systems into EU energy systems and with efficient EU and national energy policy. Society is rather passive, unorganized and lacks civic power, thus it is obvious that its possibilities to form, raise and embed selfsufficiently the public interest of energy security policy are strongly limited. Sustainable energy sector strategy should ensure its continuous implementation that is independent of the democratic government change, as well as reliable energy security for the energy users and for the whole country.

The Energy Security Research Centre provides indicators of energy safety level, currently composed of 60 factors, conditionally divided into technical, economic and socio-political blocks. Every factor has its weight in an integrated rating that is measured in a scale from 0 to 100% [3]. The evaluation of Lithuanian energy security according to the aggregated indicator is presented in Fig. 2.



Fig. 2. Dynamics of Lithuanian energy security level in 2007-2012, % [3]

As it can be seen from Fig. 2, according to the data provided by the Energy Security Research Centre, Lithuanian energy security level underwent minor changes in 2007-2012.

The following weaknesses of Lithuanian energy security can be distinguished:

- dependence on the sole supplier of natural gas (gas accounts for 70% of fuel consumed to produce the centrally-supplied heat);
- Lithuania is vulnerable in case of a malfunction of supply of natural gas and electricity or in case of big price shocks of imported energy resources;
- Lithuanian networks of gas and electricity still do not have any direct links to the Western European energy systems;
- because of very high natural gas prices, partly depending on monopolistic supplier, Lithuanian power-stations are not competitive in the electricity market;
- more than 70% of apartment buildings and a big part of public buildings inefficiently use energy. Their slow modernization can raise severe economic and social consequences.

Modernisation of buildings is one of the most important priorities of Lithuanian policy on energy independence, so it is attempted to comply with the EU requirements in this field, as well as develop Lithuanian legal acts and strategies regulating the instruments of buildings modernisation and implementation of these strategies.

Considering the problems of Lithuanian energy security. Lithuanian strategic goals in the field of energy are formulated with regard to public security and sustainable development goals. In contemporary society that is dependent on energy resources, the energy security is an important part of national security, while competitiveness and efficiency can be perceived as main assumptions for country sustainable development. It is worth noticing that efficiency covers the sparing use of energy resources, as well as economic efficiency expressed through the rational use of financial resources in energy sector. Also, considering external and internal situation and in order to reach the common strategic goals in the field of energy and ensure the energy security of Lithuania, in all energy sectors such principles as flexibility and rationality, diversification and liberalization, integration, energy efficiency, the use of local and renewable energy resources, as well as sustainable development should be implemented. The implementation of these principles in national legislation and in the practice of the energy business companies would

form a strong base to reach the sufficient sustainability level of the energy sector in the context of universal sustainability.

6. CONCLUSIONS

1. In order to contribute to the universal country sustainability development in energy sector, there is a need to provide dissemination of information on sustainable business, increasing public awareness in universal country sustainability and strengthening cooperation of stakeholders in energy sector.

2. Implementation of universal country sustainability in energy sector of Baltic States can stipulate implementation of other voluntary measures aiming at sustainable energy development in the Baltic States: increase in energy efficiency and enhance of use of renewables.

3. Strategic decisions of universally sustainable development of energy sector is mainly determined by the following points: business strategies of energy companies, development priorities, business environment, consumers (their potential), market potential, business potential (resources and skills), attained efficiency and accepted risk level. Current sustainable development and energy strategies, as well as existing mechanisms of their implementation are insufficient to influence the development of energy sector. It remains relatively closed, national, monopolized and insufficiently integrated into the global sustainable development trends.

4. Sustainability of energy sector mainly depends on country energy security. After highlighting the weak points of Lithuanian energy security, the energy strategies being performed contain the principles and instruments allowing reaching sufficient sustainability level of the energy sector in the context of universal sustainability of a country.

7. ACKNOWLEDGEMENTS

The research was supported by The Research Council of Lithuania and performed while implementing the project "Design of Investment Strategy for a Medium Size Country Pursuing for Universally Sustainable Development", project No. VP1-3.1-ŠMM-07-K-03-060.

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Adequate Educational System for Sustainable Development

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ABSTRACT

This article explores the feasibility of applying the development concept for sustainable adequate educational system and discusses the crucial role of this concept in the higher education. The purpose of this article is to outline a new conceptual framework incorporating the sustainable development elements for adequate educational system, which highlights the necessity of interests' compatibility of process participants – entrants (students empowerment), educational institution (academia/community), business, nation and NGO (public interest and (civic society empowerment). This article reports findings from comprehensive survey based on participation action research conducted in the university and schools in Lithuania.

Keywords: Sustainable development, adequate educational system, Civic Participation, Public Interest.

1. SUSTAINABLE DEVELOPMENT CONCEPT FOR EDUCATION SYSTEM

Globalization, digitization and transformation of society accompanied by increasing migration, changes of sociodemographic structure and other trends of modern world pose new challenges for education enabling the search for adequate educational system for sustainable development. Socio-economic crises that overwhelmed the world led to discussions on the topic of sustainable education by major international organizations and institutions – for example, United Nations and European Union, as well as scholars, actualizing it as response to these challenges.

Conceptualization of sustainable development is closely associated with the concept of sustainable development that is named as: "the development satisfying the current needs of society without prejudice the possibilities of future generations to satisfy their own needs" in Brundtland report prepared by initiative of United Nations [24]. This definition was also developed at United Nations conferences in Rio de Janeiro [29], where sustainable development has been validated at the highest level as a key long-term strategy of society development and Johannesburg [26], providing national strategies of sustainable development were approved. Under the decision of United Nations General Assembly the ten years period from 1st January 2005 is named as decade of Sustainable development education and the strategy of Sustainable development education was prepared by initiative of United Nations Economic Commission for Europe. UNESCO strategic document [28] emphasize that sustainable development education is an integral part of lifelong learning perspective involving all possible formal and non-formal education spaces from the early childhood to maturity [10]. Recent international documents gave impetus to approval of strategic documents in Lithuania [20; 21]. The objective of the latter program aims to increase the in formativeness on sustainable development and its importance:" to develop the capacities, values and incentives of all members of society to act responsible and democratically - to contribute to the implementation of sustainable development goals; to develop the ability of institutional structures to actively participate in the processes of sustainable development". This document also expresses the aim "to create the conditions of sustainable development education, to improve the quality of formal and non-formal education, self-awareness and society information allowing every person to contribute to sustainable development personally, by his professional activities and participation in society life locally and globally" [21]. Education of sustainable development mirrors the concern for education of high quality, characteristics (interdisciplinary demonstrating and multisectoraly (holistic); valuable substantiation; innovative education: common decision-making: adaptability; local significance). Education of sustainable development is an integral part of lifelong education perspective involving all possible formal and non-formal education spaces from the early childhood to maturity

[10]. Sustainable development context is shaped by the global development framework beyond 2015, the target date for the Millennium Development Goals (MDGs). Dakar Framework for Action on Education For All [27] and Global Thematic Consultation on Education and the -2015 Development Framework [23] play an important role in building sustainable education system and highlight quality, lifelong learning adult literacy, inclusive education, gender equality beyond parity of access. The concept of sustainable education evolving in the context of sustainable development, which is tried to be legally regulated by politicians at international and national levels, lacks of complex theoretical definitions describing the content of context holistically. A sustainable education dedicates a high importance to the education on sustainable development in its definition and is characterized with another unique element - the sustainability that interacts horizontally, vertically and integrally within the educational system. Therefore, given the efforts of politicians to consolidate the concept of sustainable development in the education, the risks associated with the creation of value for concerned persons, its measurement and management are identified.

2. METHODOLOGY OF THE RESEARCH

Many academics [18, 16, 30], who examine the action research note that although the valuable results are obtained by action research which may be difficult to get using other methods of research, but an issue of their reliability raises here as well. It is important to evaluate whether the implementation of the project and issue solution were achieved in accordance with the principles of democracy, e.g. through cooperation and openness involving all groups of participants into activity.

Other principle of expedience (eligibility) determining the validity (in this case the concept "validity" is identified with "reliability") of research defines whether the project could be implemented in the organization taking into account the specific situation. The accuracy of the research should also by typical, assessing of what is involved in the research, what was their activity, what data were obtained and what procedures had to be taken to obtain them etc. Of course, we should not forget about the limitations of research results in the other environment determining insufficient validity of external action research.

The author [18] emphasizes that democracy of action researches is a result of management theories (equal rights to make decisions, common values and goals and so on), so it could be hard for the researcher to actualize a research by emphasizing the democracy where hierarchical, formal and bureaucratic structure prevails in the organizations. The same author quotes and recommends focusing on four issues: 1. How the researcher – practitioner should choose fair and costeffective methods to collect the research data and process them if he is employed full-time at his direct work and has a limited time. 2. How many methods of research and technical procedures should there be in relatively smallscale research not to accusing the researcher for insufficient validity of research. 3. How the practitioners will be able to adapt the research methods based on their competence. 4. How these methods will improve the understanding and researched situation. An issues can also occur due to the fact that organization managers, middle chain managers and employees for which the changes resulting from these researches will not be handy may resist to the research performed by researcher practitioner. Action research - which is also known as Participatory Action Research (PAR), community-based study, co-operative enquiry, action science and action learning - is an approach commonly used for improving conditions and practices in a range healthcare environments [18, 16, 30].

Participatory action research was organized referring to innovative educational activity - the methodology of problem based method (called project "Citizen", prepared by Education and Training Centre (USA), involving the students of Social Pedagogy Department in the Social Communication Institute of Lithuanian University of Educational during the course "Civic Education and NGO". Various methods of research involving the analysis of written student texts (reflections), documents group projects under the (described relevant methodology) and questionnaires (specific information and feedback) ensuring the reliability of results was used during the participatory action research.

Participatory action research was organized referring to basic stages described in the theory [18, 16, 30, 15]:

1.1. Planning. During the planning stage, the 2nd year students from university were introduced to the methodology of project "Citizen" prepared by Education and Training Centre (USA) in an autumn study module "Civic society and participation". The autumn session involved six stages - identification of community issues; the selection of addressed issue; search for information about the addressed issue; the preparation of documental entirety; introduction and discussion of project results [3]. The prepared documental entirety shall explain the selected issue, assess the alternative policies and solution possibilities, provide the solutions offered by project participants and provide the action plan [17]. After the project' simulation during the lectures, group of students have selected educational and social institutions where they organized the activity with children based on the methodology of project "Citizen". During the planning stage, it was foreseen for the students to organize weekly meetings with children and conduct the activity based on the mentioned methodology. Achievements and challenges were discussed in a weekly lecture "Civic society and participation".

1.2. Action. The action stage of project "Citizen" involved the following activities: formation of student groups, selection of educational or social institution, approvals of administration and coordinating teacher / educator of selected educational or social institution to participate in the project, staged implementation of the project and public presentations of the project in a

community and national level (it is recommended to present the projects in a selected or social institution; the presentations of the best projects were made in the Parliament of the Republic of Lithuania. Students divided into groups of 5 people on average mainly selected the secondary schools to implement the project. The project annually involved 8 project presentations on average (youth schools, gymnasiums, non-formal educational institution). The project "Citizen" is approved by Ministry of Education and Science of the Republic of Lithuania, therefore its methodology may be applied in the lessons. Groups of students individually consulted with the institution's administration on each case of particular class or group. After the implementation of each stage of project "Citizen", students wrote reflections and prepared the entirety of documents with the pupils. They also answered to some questions in a free form after the implementation of the project.

1.3. Monitoring. At this research, students were the participants and organizers of the research. During the organization of methodology of project "Citizen" in educational or social institutions the students had a possibility to monitor the process from the side and have the positions of researchers collecting various data. At the same time the students were responsible for efficient implementation of project "Citizen".

1.4. Reflection. This stage involved the data collection of various levels, e.g. written texts of students (reflections), documents of project "Citizen" (of described group projects) and questionnaires for students (specific information and feedback). The conclusions and recommendations of each stage on implementation of next stage were prepared based on data analysis. During the implementation of project "Citizen" some more data, e.g. pupils survey after the project implementation and group interview of students have been collected. Implementation of the last stage - reflection allowed to project next steps. Three participatory action research cycles of project "Citizen" have been implemented within three years and they helped to establish the expression of intercultural communication educational innovations and its determinant assumptions.

Demographical data of the research

Participatory action research has been performed during 3 year period involving the students of Social Pedagogics Department Social Communication Institute of Lithuanian University of Educational Sciences. The methodology was simulated in the auditorium and adapted in different schools. Different methods of research were used during the participatory action research: analysis of written texts of students (documentations) (reflections), portfolio and questionnaires (specific information and feedback), ensuring the reliability of results (reference of students who participated in action research is provided in Table 1).

Table 1. Refer	ence of students	who	participated	in	action
research.					

Cycles	The	Male	
	number of		Female
	participated		
	students (total		
	number of		
	students in a		
	year)		
Cycle I	55 (57)	2	53
Cycle II	44 (48)	3	41
Cycle III	60 (65)	5	55

Organization and progress of the research

Participatory action research was organized based on the basic steps described in the theory: planning (introduction to the methodology, simulation during the lectures); action (formation of student groups, selection of educational or social institution, staged implementation of the project, public presentation of the project); monitoring (the student were the participants and organizers of the project), reflection (data collection of various levels, e.g. written texts of students (reflections, etc.).

This methodology helps the participants to monitor and influence public policy in the development of democratic values and principles, promotion of tolerance and understanding of politics [3]. Other sources define the program as learning tool designed to develop the knowledge, skills and tendencies encouraging civic participation in community activities [17]. The methodology is successfully applied in more than 70 countries worldwide and implemented in Lithuania since 1995. It involves six stages: identification of community issues; the selection of addressed issue; search for information about the addressed issue; the preparation of documental entirety; introduction and discussion of project results [3]. Exploring participation action research methodology as a concept this research involved various methods. During the activity research has been used: written texts of students (reflections); documents of project "Citizen"(group projects) and questionnaires for students (specific information and feedback) illustrated in the figure No 1 (Fig. No 1. Research methods) analysed using the method of content analysis.



Fig. 1. Research methods

3. SUMMARY OF FINDINGS

The scientist [18] is recommended to interpret the results of qualitative researches and adapted to summarize the results of participatory action research [18, 13] by evaluating positive and negative aspects of direct or indirect impact. The research highlighted the essential aspects helping to identify the assumptions for adequate educational system for sustainable development. The results of the research revealed that adequate educational system for sustainable development might be analysed by invoking the categories of *empowerment active participation, motivation, partnership* (communication and cooperation) and *feedback*.

Respondents of the research rated certain aspects very positively, for example, "Opinion telling", "Collective decision-making", "Information search", "Assessment and self-assessment" (direct impact) and "New partnerships" and "Publicity" (indirect impact). There were no exclusively negative factors observed. Other factors distinguished by both positive and negative factors.

A positive direct impact identified in subcategory "Opinion telling" of category "Active participation". Informants emphasized the importance of democracy and equivalence principles and give the right to all participants to express their opinions (it is important that everyone could say what they think; I am afraid to speak in public thus the used method helped to express the ideas; I was pleasantly surprised to hear all opinions; it is interesting how differently we see the community problems and their solutions; although some opinions seemed absurd they were very helpful finally). Positive elements of intercultural communication is highlighted in the context of different opinions (it is worth to accept the different opinions; we all thought differently in the group and therefore we offered the best solution; it was difficult and later fun to understand the other choice or suggestion; I became more tolerant; I could suggest to rather listen to the other persons than themselves).

A positive direct impact identified in subcategory search" "Partnership "Information of category (communication and cooperation)" that included effective cooperation within the team (stronger teams fared better; we understood each other without a words; we distributed the tasks quickly; the decisions were made by all of us; we did not vote without arrangement) and outside of it (the school friendly allowed to question the pupils, I was in this institution earlier so it was easy to agree; surveyed students were friendly and nearly all of them responded to the questions; the municipality willingly provided the necessary information; the police did not want to talk to us straight away but they agreed and helped us when we explained the situation).

A positive direct impact identified in subcategory "Assessment and self-assessment" of category "Feedback" identified as quality control (*we achieved better results by working together and often discussing; we presented our reports every week; we were all* connected and therefore we strongly cooperated and helped each other) and including discussion of results (I was happy although the others achieved for more; it is interesting to hear what others did; it is fun to enjoy the work together).

4. DISCUSSION AND CONCLUSION

Systematic approach to adequate educational system for sustainable development reveals 4 main dimensions: empowerment of active participation, partnership (communication and cooperation), project presentation and feedback.

It is important to point out that prediction of the interests of process participants - entrants (students' empowerment), educational institution (academia/community), business, nation and NGO (public interest; civic society empowerment) - is crucial and already discussed in different studies. Communities and NGOs are an integral part of the social economy, which is recognised as increasingly significant in finding solutions to challenges. The scientist [19] defines the social economy as all areas which are not aimed at private profitability, but have impact in positive developing of socio-education environment, for example: social enterprises, philanthropy, NGO, socio-educational networks, households and non-formal associations. In this economy, citizens can become an active participant. In order to be effective they need competences of how to use human and other resources, social communication skills for alternative project based models, which can solve or find design for socio-educational problems or environmental challenges. Radical new ways of working collaboratively at all: local, regional, national and global levels are needed; not just to come up with new ideas, but also to better access and work with the value that exists within communities [22, 2]. Components of the attitudes (such as motivation and participation) are emphasized in of intercultural communication researches and competences [25, 7, 3, 14], analysed in connection with skills and knowledge (needed for communication and cooperation and social partnership). Such collaborations based on the project "Citizen" reflect how communities, self-defined by identity, place or interest, are at the heart of successful innovation. Students can serve as major actors in the development of the positive socialization and the protection of children's welfare, as well as creating an effective socio-educational assistance system [1, 5, 8]. Society - business, nation together with NGOs and other public agencies and extra-curricular organizations through innovative methods like project "Citizen" would play a significant role in the adequate educational system for sustainable development. A lack of balance within children welfare policies in new democracies and other less well-developed countries creates a negative impact on the adequate educational system for sustainable development, for example, child development and the human resources, of the country [4]. The absence of the emphasis on civic and social education as well as educational system for sustainable

development in schools will limit the possibilities for some children to become full-fledged, well-functioning citizens [9, 11]. It is necessary to train professionals who are able to competently guide the socialization process within and outside educational establishments and are able to assist in the development of good citizens, educating them in civic knowledge, cognitive and participatory civic skills, and civic dispositions [12].

Social innovation such as presented methodology based on the project "Citizen" could become one of the main issue to cope with the sweeping changes occurring within its borders by taking a leading role in the formation of new ideas and the creation of new institutions to benefit the society now and for the future generations.

Furthermore it may engage in an in-depth study taking the entire school year or longer to complete. Although some action research projects have a clear final point, the action research process lends itself to a spiral of cycles, with researchers reflecting on the results of the current action in order to plan the next series of actions.

5. ACKNOWLEDGEMENTS

The research was supported by The Research Council of Lithuania and performed while implementing the project "Design of Investment Strategy for a Medium Size Country Pursuing for Universally Sustainable Development", project No. VP1-3.1-ŠMM-07-K-03-060.

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Integral Cluster of Knowledge, Innovation and Technologies as a Key Resource and Implementation Technology of Universally Sustainable Development

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ABSTRACT

Seeking the universally sustainable development of a country, especially if the country under analysis does not possess abundant natural resources, the idea is being revealed that the main and inexhaustible resource for its development becomes an integral cluster of scientific knowledge, innovation and technologies. The abbreviation for the name of such a cluster is said to be KNIT (KN knowledge, I – innovation and T – technologies). Thus the integral KNIT cluster efficiency evaluation problem should become the object of exclusive attention of national and global science. However, little work aims to propose a pragmatic solution for the latter problem. For this reason in the paper the following problem is being analysed: what should be the structure of the integral KNIT cluster, recognizing that the categories of knowledge, innovation technologies and mean the implementation of different functions of country development? Along with that, the question of financial resource allocation is being solved. The author synthesizes the existing opinions and also reveals his own opinion about the possibility to find out the interaction among knowledge, innovation and technologies in the context of value creation or resource management, when the object of the cluster becomes the project of country universally sustainable development.

Keywords: Sustainability, Sustainable development, Quantitative Measure of Development Sustainability, The Cluster of Knowledge, Innovation and Technologies, The Structure of Cluster, Universally Sustainable Development.

1. INTRODUCTION

Although the trio of categories - knowledge, innovation and technologies (KNIT) - are particularly often used together when examining the general characteristics of this cluster or examining the interaction of knowledge, innovation and technologies as subsystems, when the objects of their influence are the same phenomena or systems of reality, but in scientific literature there is insufficient attention to their structural analysis.

Indeed the interaction of KNIT cluster subsystems is particularly difficult, equivalent in complexity to the interaction of biological systems and lacking a sufficiently adequate understanding of adequate cluster structure there remains only a very uncertain possibility of influence when seeking a sustainable development of cluster as well as use of its power. There is no doubt that the structure of a KNIT cluster depends on the object, whose understanding and management requires information generated using KNIT. Such an object will be called a KNIT object.

In any case, the structure of a KNIT cluster can be expressed only with the example of an undetermined set (Fig. 1). It is clear that without the assumption of which object is in the centre of focus of the cluster, it is difficult to talk about Fig. 1, because it is a collection of unrelated (not linked by the needs of the mentioned object) knowledge, innovation and technology digests.



Fig. 1. Initial stage of formation of integral KNIT cluster [10]

There is no doubt that with the change of KNIT object, the content of cluster components and the structure of the cluster also changes.

What should a scheme or algorithm be that would standardize both the physical understanding of cluster components and their interaction anatomy, and, most importantly, allow one to understand how to change the cluster structure in order to make a particular change in the condition of cluster object, or what should be the value structure of the cluster that would allow it to optimally (i.e. most efficiently) use the investment resources to carry out its functions. In turn, it is important to understand, which of the components of the cluster becomes a carrier (potentially the most important to achieve the goals).

Integral hierarchy of KNIT cluster subsystems at this moment can be defined, in a simplified way, as follows:

• In cases where the problem is closely related to topics such as knowledge economy, knowledge society and so on, the leading subsystem is that of knowledge;

• In cases where the problem is linked to the analysis of innovation function system, the leading subsystem is that of innovation;

• In cases where the technological change or technology transmission are at the center, the leading subsystem is that of [9].

Of course, the fact that the cluster of linked knowledge is often already an innovation, the integrated knowledge and innovation cluster are a new technology and the integral KNIT cluster is a technology causes confusion when creating a scheme or algorithm to standardize the understanding of KNIT subsystem interaction.

2. KNIT CLUSTER AS A SELF-ORGANIZING COMPLEX SYSTEM IN THE PROJECTION OF SUSTAINABLE DEVELOPMENT

In this section an attempt is made to reveal the possibilities of integral KNIT cluster, both after becoming the source of country's universally sustainable development and when choosing this cluster as an adaptive complex system technology.

2.1. Integral KNIT cluster as a main source of universally sustainable development factors pertaining to a country

Considering the development projects of many countries, especially if they do not possess abundant natural resources, the idea is being unambiguously revealed that the main and inexhaustible resource for their development becomes an integral cluster of scientific knowledge, innovation and technologies. The concept "inexhaustible" in the last sentence requires special attention. Since this factor is both naturally evolving and purposefully improved, there is probably no need to talk about its inexhaustibility. However, on the other hand, recognizing that future problems become more sophisticated, and negative processes in many areas of human existence obtain catastrophic speed, we need to understand that even if the resource remains everlasting, for many subjects, including individual countries, it may become unattainable.

There is no doubt that the integral KNIT cluster efficiency evaluation problem should become the object of exclusive attention of national and global science. Unfortunately, little work aims to propose a pragmatic solution for the latter problem. What should be the structure of the integral KNIT cluster, recognizing that the categories of knowledge, innovation and technologies mean the implementation of different functions, and the need for financial resources is also formed in different ways?

In our experiment the object of integral KNIT cluster is the projection of universally sustainable development pertaining to a country (Fig. 2). The concept of universally sustainable development is quite extensively presented for the scientific community (see examples in [6], [7]), so there is no need to talk about its content and constructivism. It is only worth to mention the structure of each of the four subsystems of country development sustainability: Proceedings of The 18th World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI 2014)



Fig. 2. The hierarchical formation of components for sustainability development

- 1st subsystem PIM, composed of political (1), integration (2) and managerial (3) components;
- 2nd subsystem SEE, composed of social (4), economic (5) and ecological (6) components;
- 3rd subsystem ECR, composed of educational (7), cultural (8) and religious (9) components;
- 4th subsystem FII, composed of financial (10), investment (11) and innovation (12) components.

The schemes, positions and contents of the components are also extensively described in [4], [8] and [11].

The title of this section appeals to the fact that the integral KNIT cluster should be a key source of the universally sustainable development factors. Fig. 2 illustrates the fact that all components of universal development sustainability require the help of KNIT for generation of required knowledge, innovation and technologies. It is evident that the cluster has to be adapted to meet the needs of a specific object – the projection of universally sustainable development pertaining to a country.

The title of Fig. 2, the idea of a round table, highlights the fact that in the selection of final solution the interests of all development sustainability components or just the experts representing those interests should participate, otherwise there should be adequately formulated criteria. The idea of the round table helps to express a provision that there should be a possibility to quantify and coordinate these interests.

2.2. Integral KNIT cluster as the technology of an adaptive complex system

Understanding of technologies is, on the one hand, increasingly approaching the definition of its unique features: nuclear technologies, nanotechnologies, Internet technologies. On the other hand it reflects more and more the whole of actions and processes, principles, methods and criteria which express the possibility of transforming the original resource, for example knowledge and innovation, into a valuable product such as management system, monitoring and development strategy [5].

These are apparently the natural changes of thinking logic, because in the case of even a not particularly sophisticated supply of production or service, a network of technologies of the organization and manufacturing of production, supplying, market formation, marketing, finance and so on is formed, the perception of which itself becomes a problem. Therefore it is worth considering whether it is not better to sometimes just choose the ideology of complex network or system organization and management, without doubting that the formally identified object of understanding of the complex system and research instrumentation remained adequate to systems emergent in reality and the interaction of its subsystems and components.

An outlook forms that technologies, innovation or even technological discoveries can come from the side of managerial effort. It sends a positive signal for multiple service providers because stereotypically they usually stayed beside technologies.

Now among the titles of technologies very often are those which appeal to the business organizational side or the features of possible solutions. So, next to information technologies, the technologies of complex systems, which are oriented to the object, their mutual relations, the processes of changes and the abundance of criteria and especially the complexity, are attempting to win their place in system [14], [15].

Considering the complexity of system management practices an opinion forms [2] that it is apparently useful to choose already an professionally prepared model of the complex systems that has the ability to cover and reveal all the functions typical of a very broad class of complex systems, find the analyzed system among the whole of model's functions and identify it as the particular case. There is no doubt that it will always be the case that the particular system chosen has its peculiar characteristics and that this necessitates the development of the general model. However, it is necessary to always remember that the creation of adequate model for a wide class of complex systems is a long and costly work.

The circumstances presented above apparently form a basis to not overly generalize the understanding of technology as knowledge and skills of using the mechanical tools and applied science results [1], [3], [13] or that the technology is the totality of manufacturing process performance methods and tools [12], [16].

2.3. Integral KNIT cluster as a complex system

Projecting KNIT as a self-organizing system which could be the resource of a country's sustainability development factors and the backing force of sustainability, it is important to adequately perceive the possibilities of knowledge, innovation and technology cluster. Naturally, the formation of the cluster leads to distinction of the mission and core functions of each component, which in turn could be the base for expert evaluation of financial resource requirements. On the other hand, special attention must be given to the understanding of the role of each of the components in order to achieve the strategic objectives of a country's sustainable development [7] and which can be divided into four groups and that are presented in sufficient detail in Fig. 2. These are:

- political, integration and managerial;
- social, economic and ecological;
- educational, cultural and religious;
- financial, investment and innovation.

In turn, there is no doubt that most of the components of the country's universally sustainable development project (Fig. 2) are potential objects of an adaptively changing integral KNIT cluster, whose objectives can be achieved by means of a complex adaptive system technology or simply by means of technological support of KNIT cluster.

But at the same time it must be remembered what growth is expected of the requirements of an integral KNIT cluster so that it can adequately adapt moving from one object to another, or in our experimental case, from one project of universally sustainable development to another. But it is important to know how to choose the typical scheme or algorithm of adaptation to preserve the efficiency of the proposed methodology.

Yet the supreme requirement exists for the KNIT cluster itself, namely that by becoming an agent of social development it should not only not lose status of inexhaustible source of expansion factors, but also remain cost-effective. In the next section, by means of stochastically informative expertise the importance of KNIT contribution at each of the aggregated components of universally sustainable development is evaluated, and the optimal KNIT structure when the object of KNIT remains the same project of universally sustainable development is found.

3. THE EXPERIMENT OF INTEGRAL KNIT CLUSTER STRUCTURE OPTIMIZATION

The countries or regions, for which there is no alternative besides the integral KNIT cluster as a source of development factors, should be interested in efficiency of economic KNIT cluster and especially the problems of rational use of investment resources. These problems could be solved by optimizing the investment resources among the possibilities of KNIT in separate development subsystems and by optimizing the structure of KNIT cluster itself. Further the solution of the experimental task will be presented: how a marginal investment unit should be allocated among the development of cluster components: knowledge, innovation and technologies. The result of stochastic optimization is as follows: $w_1 = 0,19$; $w_2 = 0,30$; w_3 = 0.51. Thus the marginal investment unit should be allocated among the cluster components according the presented ratio. The solution of such task in details can be found in [10].

4. CONCLUSIONS AND SUGGESTIONS

The countries or regions, for which there is no alternative besides the integral KNIT cluster as a source of development factors, should be interested in the economic efficiency of knowledge, innovation and technologies at the same time considering the problems of rational use of investment resources.

The paper presents the solution of the experimental task: how a marginal investment unit should be allocated among the development of cluster components: knowledge, innovation and technologies. The result of stochastic optimization is as follows: $w_1 = 0.19$; $w_2 = 0.30$; $w_3 = 0.51$. This is a hypothetical solution which should be adjusted to every country's case.

Proper development of KNIT cluster using investment resources would help to reach the universal sustainability of a country, which, in turn, is expressed through the four fields of expertise: SEE (social, economic and ecological), ECR (educational cultural and religious), FII (financial, investment and innovation) and PIM (political, integration and managerial).

The application of the integral KNIT cluster as an adaptive complex system model for the cognition and projection of universal sustainable development has revealed and dictated the real problems of cluster cognition and analysis of its development.

5. ACKNOWLEDGEMENTS

The research was supported by The Research Council of Lithuania and performed while implementing the project "Design of Investment Strategy for a Medium Size Country Pursuing for Universally Sustainable Development", project No. VP1-3.1-ŠMM-07-K-03-060.

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The Projection of Country Universally Sustainable Development

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ABSTRACT

The paper presents the rudiment of universally sustainable development project for a small country that lacks exceptionally valuable or unique natural resources. This is a result of rather long experience of the author while studying the perspectives of small country development under conditions of intense globalization and conflict because of world territorial division among the different development ideologies or simply different interests. Along with that, the beginning of primary and possibilities for a self-sufficient interests development organization is analysed, as well as the formation problems of development resources and implementation technologies orienting towards the clusters of scientific knowledge, innovation and technologies. Finally, the selection of a model of universally sustainable development as a complex of instruments for development will be reasoned. The experimental assessment is performed on the example of the Republic of Lithuania case.

Keywords: Universal Sustainability, Sustainable Development, Quantitative Measure of Development Sustainability, Complex System, Stochastically Informed Expertise.

1. INTRODUCTION

Sustainability can be defined as an ability of a subject to retain certain functions. The concept of sustainability and especially sustainable development dominates in the literature among the most ambitious and controversial concepts [2, 3, 5, 16]. The knowledge and researches of evolution or development become not only the original means of generation of socio-economic science knowledge, but also an alternative in analyzing especially sophisticated development problems – such as survival, effective changes, avoidance of huge losses, etc. Finding the ways of such knowledge conversion into the field of science is complex, but there is no alternative. Researches of development have already become mass, and thus the

objects of cognition should be structured, possibilities should be consolidated and the efficiency of the use of resources must be elevated [12].

The paper analyses the following problem – how to select an optimal structure of investment resources in order to retain and ensure the development sustainability for a small country that does not possess abundant natural resources and, as a result, can use mainly intellectual resources while nurturing its own development.

2. THE ANALYSIS OF THE STRUCTURE OF SUSTAINABLE DEVELOPMENT SYSTEM

The strategies of retention or development of sustainable system of Lithuania as an independent country constitute the particular object of the conducted research, where these strategies are grounded by the historically formed need for the retention of country self-sufficiency and ability to generate and implement the intelligent development strategies. The guarantee and motto of survival of Lithuania as a self-sufficient country is the historically formed intelligence of self-sufficiency retention and development. Immediate assumption of country self-sufficiency survival and successful implementation of development strategies is the intelligent use of natural, as well as human-possessed and created resources. The main guarantee context of country development effectiveness and success is a universally sustainable development. Here in order to touch more thoroughly all the peculiarities of development, as well as to use all the created powers, the following subsystems of country sustainable development are distinguished: religious, political, social-demohraphic, economic, educational-professional, creative ecological, and cultural, innovative-technological, integrative, marketing, financial and investment.

In Fig. 1 the conception of interaction among subsystems' and the whole of instruments for decision formulation and search is presented: the information systems of knowledge, decisions management, uncertainty evaluation, as well as stochastic models of quantitative decisions and expert evaluation. However, the evaluation of separate problems should be recognized here as the exceptional moment, when with the help of the gathered and generated information a search for the compatibility of different aspects of development is performed.



Fig. 1. Formation of components delivering the development sustainability and preparation of the means of knowledge and expert valuations pursuing the possibilities of development sustainability management and the idea of the round table [13]

As a separate challenge while analysing the sustainable development problems in the context of systems' methodology a question arises on the unification of measuring dimensions of separate subsystems and the effectiveness of the whole system. First of all, let us remind that sustainability measurement is related with two-dimensional measures – effectiveness and reliability. Reliability has an undimensional way of measurement, but while measuring the effectiveness one cannot get along without the indicators expressing the content of existence of subsystems or the whole system, such as created product, grown harvest, etc.

Also, in complex systems it is accepted that in the reality serving as the object of their cognition the possibilities exist that the state of one subsystem can be a factor of the other subsystem's state, that ultimate indicator of the state of the whole system or its generated effect can be a complex function of separate subsystems' indicators. But the most difficult problems arise when it is necessary to solve the key economic problem – how to allocate rationally the possessed scarce resources with the objective to orient the system's movement to the optimal state or trajectory.

3. INTELLIGENCE OF THE SUSTAINABLE DEVELOPMENT SYSTEM

Thus we approach the perception of intelligence. Intelligence uses the definition of knowledge as a system to form a vision of potential development ways and methods that help to select the unique manner of work. In order to know or accept this contradictory situation, we should admit the dialectics of scientific knowledge and engineering, as cognition methodology: the science reveals the possibilities of what can be, while engineering focuses on what and how to do it. Treating knowledge, innovation and technology set as an integrated system, it is necessary to understand the diversity of situations, trying to make their integration be directed towards achieving the strategies.

In the performed study the particular objects are sustainable strategies of system maintenance and development for Lithuania as an independent country. These strategies are based on historically developed national self-maintenance needs and the ability to generate and implement intelligent development strategies. The guarantees and motto of survival for Lithuania as an independent country is historically formed intelligence of self-maintenance and development. Immediate premise of country independent survival and successful implementation of its development strategies is intelligent use of natural and human, available and emerging resources. The main context of country development efficiency and guarantee of success is universally sustainable development [15]. For a more detailed analysis of all development accents and application of developed powers, the four sustainable development subsystems of a country are distinguished: PIM, SEE, ECR and FII (Fig. 1), and their primary detailed description is presented in the article of Rutkauskas [10] that is intended to explain the concept of universally sustainable development. Further, each subsystem will be shortly described, highlighting the role of intelligence:

PIM. This group is described through the possibilities to guarantee the representation of public interests in international institutions. The intelligent integration of a country into the local, regional or global organizations of national or economic security that guarantee safety under acceptable costs for a country is projected. Also, using the principles of marketing, the sustainable flow of import-export should be ensured along with the development of the utility provided by the results of general social and economic programs.

SEE. This group describes the ability to match the interests of different social groups relying on scientifically proved consistent patterns. Also, it is aimed to use rationally the internal and external resources in order to reach the desired value, in the same time maintaining diversity and efficiency of country's biological systems.

ECR. This group is described through the ability to combine learning and creativity while training business analytics and knowledge economics and striving for the balance of supply and demand in the labour market, as well as through the recognition of spiritual values of humanity. The ability to create something new and valuable using intelligence is trained.

FII. This group describes the ability to ensure the use of modern technologies based on the most efficient innovations. The power of financial system is attained, which allows for a public sector to ensure the required financial resources to implement the international liabilities.

Thus considering the nurturance of country universal sustainability it is necessary to pay attention to the ability to integrate intelligence, knowledge, innovation and technology management while solving the issues of small country development.

4. THE ASSUMPTIONS OF OPTIMIZATION EXPERIMENT ON RESOURCE ALLOCATION

Based on the assumption that sustainability of national development, sustainability [1, 17] can be examined using a model of a complex system, we have to admit that the corpus of elements existing in reality would have the following characteristic features:

- a very complex system;
- high sensitivity to even the smallest changes in dependencies between components;
- its identification and verification is difficult even with the knowledge of its design or function, or both;
- it is characterised by abundant interactions between different components;
- with time, it may reveal new features or states [14].

There is no doubt that all of these characteristics are particular to the phenomenon of national sustainable development. However, if it needs to remain an open and self-regulating system, the functioning of which required resources, which may not only lead to changes in internal dependencies but also in the effect created by individual subsystems or even the entire system whilst turned into input elements, then, there should be an agreement that the system, the content of which is comprised of abovementioned features, requires the design of adequate possibilities for its understanding and management [6].

The study conception of interaction between the subsystems, formulation of solutions and the set of instruments for solution search: the systems of management information knowledge, solutions, uncertainty assessment and the models of stochastic quantitative solutions and expert evaluation, is presented in the previous author's articles [9, 10]. But at exceptional moment here we have to recognise the assessment of separate problems, when on the basis of collected and generated information is searched interoperability between different aspects of the development. And the fact that here invoked so-called stochastic informative examination methods for expert evaluation.

Examining sustainable development problems in the context of methodology for complex systems, a question emerges regarding the alignment of performance measurement dimensions used for separate subsystems and the entire system. It should be reminded that sustainability measurement is two-dimensional, namely, aimed at efficiency and reliability. Reliability has a dimensionless measurement method; however, the measurement of efficiency is impossible without indicators that represent subsystems or the content of the entire system [14].

However, the most difficult problem arises when dealing with the fundamental economic problem of rational allocation of scarce resources aiming to direct the system toward the optimal state or trajectory.

5. ILLUSTRATION OF EXPERIMENTAL SITUATION SOLUTION

Further temporarily simplifying the situation let us suppose that the state of every subsystem can be measured with undimensional indicator and that using the stochastically informed expert valuation one can determine the effectiveness of marginal investment unit, if it is used for the training of i^{-th} subsystem functioning. Then we can form a task – how one should search for the optimal allocation of resources among the subsystems under the conditions of uncertainty.

To solve the mentioned problems the logics and technique of adequate portfolio will be used, that is created, described and further developed by Rutkauskas [7, 8]. The adequate portfolio can be treated as natural extension of the modern or Markowitz portfolio [4], because instead of the mean value of the effect of possibilities all the possibilities are used and the parameter of reliability is introduced [9].

Let us say that expert valuation evidences that the possibilities of the use of marginal investment unit under the certain investment proportions among the distinguished subsystems, as well as inside the formed subsystems, to change the index of every subsystem's state (which is a priori treated as one) can increase along the following stochastic multipliers:

 $D_1(a_1, S_1), D_2(a_2, S_2), D_3(a_3, S_3), D_4(a_4, S_4),$

where a_i , S_i are the mean values and standard deviations of the random variables.

Let us try to determine by what proportions we should divide the marginal investment among the distinguished subsystems if the indicator I of the whole system's state is being formed as a weighted average of subsystems' indicators I_i :

 $I = w_1 I_1 + w_2 I_2 + w_3 I_3 + w_4 I_4.$

Let us analyse the following case:

1. When the situation is complex and the mentioned variables achieve specific forms that are typical for these subsystems: D_1 becomes Gumbel, D_2 – LaPlace, D_3 – stays as Normal and D_4 as Lognormal probability distribution.



a) The general scheme of decision search



b) The surface of possibilities



c) Finding the solution

PIM	SEE	ECR	FII
subsystem	subsystem	subsystem	subsystem
Gumbel probability	La Place probability	Normal probability	Lognormal probability
distribution	distribution	distribution	distribution
0.26	0.32	0.2	0.22
Parameters:			
e _x - 1,151202			
$p_x - 0.57$			
$r_x - 0,029649$			

d) The structure and parameters of the solution point

Fig. 2. Optimal allocation of resources among the four subsystems

2. The selected probability distributions are described by the following mean values and standard deviations:

 $\begin{array}{l} a_1=0,94;\,s_1=0,03;\\ a_2=1,22;\,s_2=0,06; \end{array}$

- $a_3 = 0,99; s_3 = 0,05;$
- $a_4 = 0.90; s_4 = 0.02.$

The results of finding the optimal investment portfolio are presented in Fig. 2.

The section a shows the general scheme of solution, when indifference curves approach the surface of efficient possibilities. The surface of possibilities itself is presented in section b. Section c shows the point of optimal solution in the two-dimensional plane. And section d presents the parameters of solution. The values of the four subsystems show the structure of allocation of investment unit among the development subsystems. In the analysed case the biggest part of the investment is given to the second (SEE) subsystem -0.32. Further the parameters of solution are presented: e - efficiency (profitability), p - reliability and r - riskiness.

6. FURTHER TRENDS OF RESEARCH OF UNIVERSAL DEVELOPMENT SUSTAINABILITY

The universal sustainability is an ability of a state, process or system to retain a certain collection of functions which guarantees the existence of a system and the accessibility of a structure. In the previous section the solution to the problem of optimal allocation of resources is presented, when the marginal investment unit is divided among the four sustainability subsystems responsible for separate areas of activity. This is an innovative and adequate instrument for efficient use of investment resources.



Fig. 3. Shifting development code

By its essence the sustainability is not a status quo; while situation is changing, its effect can also grow or diminish. However, the system whose sustainability is being analysed in the paper should possess a shifting development code (Fig. 3). Otherwise it is a matter of time before the system disappears or degenerates. The integral KNIT (knowledge, innovation and technologies) cluster [11, 13, 14] with its object being the country development becomes a generator of the key scientific knowledge, describing what development strategies, with regard to the changing conditions, would allow to keep the shifting development. In such a situation the innovation and technological subsystem of the cluster will guarantee the implementation of the selected development strategies. Thus it is advisable to elaborate the researches of KNIT cluster as a shifting development code in the context of retention of sustainability state.

7. CONCLUSIONS AND SUGGESTIONS

Immediate premise of country independent survival and successful implementation of its development strategies is intelligent use of natural and human, available and emerging resources. And the main context of country development efficiency and guarantee of success is universally sustainable development

Sustainability should be analysed as a complex model of systems that possesses respective characteristics. However, such a system remains an open and self-regulating system, where resources are used in the form of inputs and they can change the internal interdependencies inside the system.

The paper presents the solution to the problem: how to optimally allocate investment resources among the four sustainability subsystems (PIM, SEE, ECR and FII) under conditions of uncertainty. The solution to this problem is an innovative and adequate means to reach the universal sustainability of a country.

Using political, integration, marketing, socialdemographic, economic, ecological, creative, religious, innovative, financial and investment factors capable to efficiently influence the state and development possibilities of a country, the possibilities of development can be broader named and analysed, as well as a more powerful synergy of factors' interaction can be created.

The shifting development code, the background of which is the KNIT cluster (knowledge, innovation and technologies), is a deep trend of further researches that can be undertaken while analysing the assumptions and means of ensuring the sustainability of a small country.

8. ACKNOWLEDGEMENTS

The research was supported by The Research Council of Lithuania and performed while implementing the project "Design of Investment Strategy for a Medium Size Country Pursuing for Universally Sustainable Development", project No. VP1-3.1-ŠMM-07-K-03-060.

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Sustainable Investment Return as Main Indicators of Universal Sustainability Efficiency

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ABSTRACT

The objective of this article is to identify possibilities to get sustainable investment return in financial markets with regard to globalization processes. The universal method of investment is offered in order to save the interest of investors - to expand the geography of investment, not leaving without attention innovative activities, but which has become global in financial market segment and thus strengthening the financial system's ability to contribute significantly to the globalization and sustainability. The main target chosen by the authors is a sustainable return on investment possibilities. It is measured using such parameters as expected investment value, expressed with a certain size of composition of return and the reliability maximization.

Keywords: Investment, Adequate Portfolio Model, Globalization, Uncertainty.

1. INTRODUCTION

In recent decades the phenomena of globalization found themselves in the center of academic community and the public media spotlight.

Along with that, discussions appear on the content of deep reasons that determine the globalization intensity, propulsions, social forms and perspectives that transform into subjective evaluations determining the interests of various social groups and behavior. Thus the approach to the consequences of globalization leads to people practical action, or even provoke social conflicts, so the main focus should be given to innovative policy solutions in the era of globalization. Globalization, for this purpose, must be understood not only as a process of extending the interaction between the public and the events, with which directly related sustainability of human existence but also as a cause, which may open the way for uncontrolled conflict.

Many scientists understand and define globalization as a process, taking place in the social environment and covering the variety of public, state and social structures areas of activity and their environment that occurs with intensification of mutual relationship and movement of time and the flow globally.

Beck [1] puts forward the idea that globalization is not a choice of business, countries or organizations, it is therefore necessary analyze not only the economic effects of globalization, but also political and cultural. If globalization is compatible with all institutions in each country, then all the influenced results will be unpredictable and unstable, so it is necessary to examine the nature of globalization.

The fact that more areas than social processes are covered, the economy and ecology do not mean
that the initial – on the basis of the three mentioned components formed sustainable development problems are solved. The pragmatic reason is that solutions of management development depend on significantly larger set of circumstances [17].

One of the most urgent questions – what will be the status of globalization sustainability of the earth, or what is meant by sustainability of human existence on development of the process of globalization.

Many scientists [10, 12, 19, 21] in their works emphasize that globalization is an irreversible process, which often is presented as a huge international market, the information revolution, universal promotion of human rights, the global industrial culture, polycentric international policy for the influence on daily lives of people. This is the core moments of the positive effects of globalization.

However, in another side of the visible and the negative effects of globalization on the lives of people all over the world – global pollution, international cultural conflicts, natural disasters.

Together in scientific literature with particular attention it is attempted to reveal the way by which interest intensifies globalization.

According to Held [8], the chunky capital of financial markets is dominant in the interests of all over the world, therefore, the process of globalization taking place on global equity interests. Whereas the passing force of globalization is globalization of financial markets, it is important to know the adequate forms and motives of capital movement in the financial markets. Capital travels accompanied by innovative capital solutions and emerging individual interests. Therefore, it is particularly important to understand the anatomy of the decision becoming in global capital market.

The main purpose of the article is to identify investment decision making scheme and methods analysing the following issues:

- Identify and disclose the main globalization processes and assumptions in the key globalization highway – international financial markets;

- To show that global financial markets are effective partners of various businesses in non-global areas searching for optimal portfolio structure in financial markets.

The main research methods selected were adequate investment portfolio model, stochastic optimization, and utility function.

2. REVIEW OF LITERATURE ON GLOBALIZATION

Globalization is especially powerful tool for the new world economic system, and in the formation of international relations. While talking about globalization, many scientists and academics examine different types of globalization and use the term of globalization for related but different phenomena description: the economic, social, political and business effects, therefore the measurement of globalization must be complex. There is a need to measure the phenomenon of globalization as a whole, i.e. to establish an integrated set of indicators - globalization index in order to determine the degree of globalization of different countries. The most famous and most cited are two globalization indices that combine the separate fields of globalization indicators: Kearney [9] globalization index and Dreher [4] globalization index. Kearney globalization index comprehensively measures the resolution of globalization processes and covers the most important displacements globalization components, which include international relations, international trade, financial flows and information flow of people and ideas across national borders [9].

Another index used to assess the extent of globalization – Dreher globalization index, calculated since 1970. This index includes evaluation of three main areas of globalization: economic, social and political.

In many scientific works the arguments can be found identifying globalization as phenomenon which leads to substantial changes in the world and creates a new business environment where a business or economy entities re-take the leading business solutions [2, 5, 8].

World economies are increasingly integrated into the global economy. Such process is conditioned by the stimulus strength of globalization. It is possible to distinguish following reasons and assumptions of globalization: the global use of land resources, the convergence of existence quality, globalization challenges for state of the sustainability. the economic efficiency of development, discoveries technological and opportunities, communication improvement, crosscultural integration, adequate opportunities of education and qualification, fundamental scientific discoveries and technological opportunities. These are the main factors that create the potential for economic activity and its entities for allocation of resources on a global scale.

According to some proponents of globalization [17, 22] a systematic understanding of the global economy in the first place puts the user of global market, because in the emerging area of global economy the user becomes the main leverage of globalization. Therefore, it is important that the subjects of world economy are involved in the integrated supply and production systems at the international level, and, as more fully, incurred the opportunities offered by globalization.

3. THOROUGH COGNITION OF GLOBALIZATION PROCESSES

Globalization is an exclusive feature of modern financial markets because around the world the general investment environment is created, as well as rapid development of integration between national markets. Currently, investors are not confined to opportunities of their own country markets, using the extensive opportunities of information technologies and the development of financial institutions; they also effectively operate with their resources in international markets.

Searching for interactions of globalization with the development peculiarities of global, regional and national financial systems, the process of globalization can be structured on the basis of D. Held *et al.* [8], submitted thoughts about three main schools of hiperglobalists, skeptics and transformationalists. These schools cannot be equated with traditional affinities but the definition of globalization in this paper is defined on the basis of each school approach to:

- concept;
- driving forces;
- socio-economic implications;
- influence for state power and governance;
- historical perspectives.

Of course, the influence of globalization is more important to the financial markets of developed countries [6]. Increasing impact of financial globalization can promote the imbalance for all the countries of the financial markets and lead to financial crises.

A wide different set of indicators is used to determine the extent and consequences of globalized finance [14]. International financial flows also play a big role in globalization of finance.

The maturity of the global financial market is measured according the behavior of the national interest rate. Although the interest rates have become increasingly more similar in many countries, for this day – they are different (the diversity of interest rate is within one country), and these differences persist even when interest rates are expressed in terms of a single common currency. Such differences emerge due to imperfections in financial markets and different economic and business development level of the [8].

Since the prevailing interest groups in the world touch one of the main highways of globalization the global financial market, it is important to correctly identify their arguments. According to Held et al. [8] provided ideas of three schools, which interact in the context of globalization, it is identified the prevailed interest forms in the world hiperglobalists, skeptics and transformationalists. Hiperglobalists and skeptics submit their arguments that existence of functioning global capital markets has leaded the equalization of return on financial assets around the world. Various empirical studies allows to set that in the group of the largest national economies exist global (real) interest rate with a small and static risk premium for different countries [8]. As a result, it can be concluded that long-term interest rates emerges in the developing global capital market, despite the fact that interest rates do not level out. The formation of real global interest rates indicates the global credit demand and supply [7]. This means a relatively high level of world financial centers interfaces and growing financial integration [3, 13].

It can be inferred more adequately about the impact of the globalization process for the world from the circumstances of the formation rate of return for each financial active similarly to profitability rate in currency exchange and capital markets, where dominated interactions of supply and demand and profitability value is visible in the event of the supply and demand balance [15]. The emergence of profitability values is appropriate to monitor in the context of uncertainty, i.e. after development a distribution possibilities probability rate.

It is thus possible to monitor how objectively are formed the assumption of financial assets rate of return - the possibilities probability distribution for the specific market. These opportunities in every market and every moment are different, but they obey for a given standard, i.e. enough to accurately and reliably approximated by one of the probability distributions [15].

4. ADEQUATE PORTFOLIO AS A TOOL ENSURING SUSTAINABLE INVESTMENT RETURN

Assumption made about the fact that during intense globalization the behavior of financial markets is converging, since it enables to expect the individual investment opportunities in different markets. However, analogous opportunities for investor should ensure the homogenization of market behavior. If an investor wants to invest successfully in different markets or choose portfolio investments from different actives of the market, he is available to select universal tool for investment decisions. In this experiment, for such a role adequate investment portfolio [15] has been invoked. The adequate portfolio allows quantitatively:

- take into account the efficiency of opportunities distribution and submitted compositions;
- practically approximate measures of financial risk;
- uniquely assess any potential opportunities of portfolio return on the basis of their efficiency, reliability and risks.

The formation of investment portfolios are based on modern models: Sharpe, Markowitz, Treynor et al. [11, 20]. Using historical simulation, Markowitz and many other scientists use the arithmetic average of return in order to determine the expected profitability. However, the average may not reflect the actual expected return on financial instrument due to presence of uncertainty in financial markets and cyclical fluctuations, because, in the opinion of authors, these widely used approaches are insufficient for finding a constructive investment decisions.

In many situations of the investment it is necessary to assess all possibilities for an investor in order to choose the best, so for the decision making of investment the authors rely on adequate portfolio.

The anatomy of adequate portfolio is based on Markowitz portfolio, because of our understanding, the adequate portfolio – is a natural extension of the Markowitz portfolio.

If the set of possibilities of Markowitz portfolio generates an effective line, where the possibilities of optimal solution concentrate and each of them is described as possibilities of average profitability and riskiness, then the bouquet of possibilities for adequate portfolio generates the bouquet of effective lines.

Below (Fig. 1), if the optimal solution in Markowitz portfolio is indicated by tangency of efficiency line and utility curve (Fig. 1, section a), the optimal solution in adequate portfolio is found by tangency of return surface (section b) with surface utility function (section c).



Fig. 1. The possibilities' surface of adequate portfolio and investor's utility function

Thus, in Fig. 1 we can see that in case of Markowitz portfolio the optimal solution is defined by the average of return and riskiness, whereas in adequate portfolio – the size of return, reliability of return and riskiness of return. More precisely – it's a riskiness of return, defined by Markowitz random field as the riskiness of random size [16].

5. RESULTS AND DISCUSSION

If you look at the investment assets content that is influenced more by the globalization processes, it is easy to recognize that time lines characteristics of previously listed return, extract the intensive nature. Firstly, this is foreign exchange market, the prices of producer's stock markets with high globalization tempo and so on.

At the same time, attention is focused on the identified probability time intervals and distributions, used for investment return description. Such parameters as the averages of probability and standard deviations that usually is accepted as deterministic values and that mutual dependencies and changes over time usually is described by the deterministic dependencies clearly indexed its own stochastic nature of change. Taking into account that identification of probability distribution leads to formally simpler and easier identification of the same distributions, this allows constructive shaping of forecasting mechanism of the assets return that we are interested over time. The past fact should be particularly relevant in the market looking for the efficient investment decisions.

True, such possibilities are fully revealed in the currency markets where returns dynamic can be captured of one day or even shorter periods. Additional opportunities to achieve the adequate description of the assets return are revealed in the currency market, analysing the investment possibilities of one day step.

Now authors do not dispose the irreproachable methods to formally evaluate the mentioned parameters of such distributions by formalized methods, so here it is necessary to present the experiment – how probability distributions with the random parameters were used to construct the decision making mechanism of portfolio investment in global currency and capital markets. As it was mentioned, the expansion of the distributions makes it understandable for situation analysts and managers of decisions.

To continue, it is provided a purely academic sample. Suppose that firstly in the financial markets the practices of solutions are used, i.e. when we have only selected assets for investment and volume of capital which we intend to use. All of the following steps of the investment remain practically identical. Let's say that in this case here are the four assets of capital *i*.

So let's say that the forecasting system informs that for the first step the possibilities of expected return for each of the four assets is described in the following way:

$$N(a_i = N(a_i; \delta_i), \delta_i = N(\delta_i, \delta_i))$$
(1)

where:

 α_i – the average of normal random value,

 δ_i - standard deviation of normal random value, *I* = 1, 2, 3, 4.

Here N is a normal distribution with the specified mean value and standard deviation. These values were calculated as random values. In such a prognostic solution (the structure of the portfolio) we choose the solution that maximizes the utility function:

$$U(x, r_x, p_x) = \frac{x \times p_x}{r_x} \Longrightarrow \max$$
(2)

where:

x – the possible opportunity of the portfolio made up of the four named assets,

 p_x – the reliability of this possibility,

 r_x – the set, which includes the possibility of risk exposure.

For the solution that is described by the existing capital structure, which will give the maximum return by the selected utility function using the solution technique of the adequate portfolio.

6. CONCLUSIONS

Globalization is the whole of changes in entrails of the earth and in the nature, created possibilities of the scientific and technological innovation, differently emerging business groups and countries unions reflecting solutions and activities interaction, which has made a significant contribution to reinforce the creative power of the humanity. However, the destructive power of globalization could surpass the humanity fostered aspiration of progress and the potential how to avoid the negative consequence of globalization.

Required the extremely intelligent activity management policy of consequences and trend of globalization that humanity be able with existing resources to make globalization an ally creating a sustainable future of humanity and together formed the intellectual potential to perceive more difficult negative possibilities of globalization effects.

Special attention should be given to the financial market that globalization is a fairly significant component of integral globalization and which in turn is intersections of a variety reasons and contingencies, which requires the evaluation of fundamental knowledge and skills of the market behavior under uncertainty.

Based on practical experiments in various investment markets, authors suggest that adequate structure of portfolio is capable to generate the possible advantage return to the investor. Algorithm of selection with a high probability includes those instruments of investment which are the leaders among the considered fit for the investment assets during the investment period and which in turn are the investment instruments with the progressive activities. For the practical selection of the above mentioned structures, it is suggested the utility function that maximizes the benefit of investor.

For the description of return on assets in global, and especially becoming global markets, the probability distributions are much more flexible, if their conventional readings (deterministic) parameters are taken as stochastic values.

7. ACKNOWLEDGEMENTS

The research was supported by The Research Council of Lithuania and performed while implementing the project "Design of Investment Strategy for a Medium Size Country Pursuing for Universally Sustainable Development", project No. VP1-3.1-ŠMM-07-K-03-060.

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Classification of objects of road environment based on point clouds using reflectivity of the laser beam

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ABSTRACT

This paper presents an approach adopted by the authors to designing a system used for creating a 3D model of road communication. Measurements of the environment have been executed using the mobile measurement platform that consists of two laser measurement systems (2D scanners), high accuracy position navigation (SPAN - Synchronized Position Attitude Navigation), in the future also a set of different sensors and 6 cameras. The laser scanner captures raw data of the environment and SPAN estimates the current position. The paper describes formulas designed to process the measured distance and position into the 3D coordinate system. Processed data creates a cloud of points where each scanned point is expressed by three space coordinates and reflectivity value as well. Scanned points are consequently classified into one of the groups of objects found in the road environment (walls, road surface, trees, vertical road signs) using the described method. The presented approach presupposes utilization of the point placement information and the reflectivity information to classify the measured points. The obtained results are compared to results obtained by a classification method working without considering reflectivity.

Keywords: Classification, Point Cloud, Reflectivity

1. INTRODUCTION

A scanning of surroundings and the design of 3D model is a current topic and it is implemented in various spheres and applications. There are several steps available to perform this task. Data collection is the first and most important step in many approaches. Improper selection of the measurement method can impair the whole process or make it impossible due to unrealizable requirements (accuracy, distance, etc.). There are several approaches to obtain information and different types of information to obtain. Using laser scanners is one of the possible data collection methods most useful for our case. Methods with laser data collection are generally divided into:

- Terrestrial laser scanning: high accuracy and a static way of measurement.
- Airborne laser scanning: mobile way of measurement and ability to scan large land areas but with lower accuracy.

 Mobile laser scanning: dynamic measurements, average accuracy within other considered methods.

Data collection presented in this paper is based on mobile two-dimensional (2D) laser scanning. These systems often combine equipment for dynamic information collection (scanners, cameras) [1, 2] with positioning systems. Practical experiments were executed with the help of technical devices obtained from project "New methods of measurement of physical dynamic parameters and interactions of motor vehicles, traffic flow and road". Result of measurement by laser scanners is set of points called point cloud. Point clouds contain information about positions of scanned points; however, no information is available on which of the points represent and belong to particular objects. Therefore various classification approaches are being proposed and tested. Affinity of the same object may be expressed in different ways, e.g. by adding color aspect, unique signs or through point separation into the specific file. Our intention has been to propose, implement and test classification algorithms capable of identifying and extracting road infrastructure objects such as road surface, trees-like objects and facades of buildings. To summarize the current status, for classification of

basic objects [3] (roads [4], facades of buildings [5], vegetation [6]) information about position of scanned points may be sufficient if fundamental object features are considered, e.g. horizontal character of road surface. A bigger problem usually comes with classification of smaller objects situated close to a road in the surrounding environment (traffic signs, street lamps, billboards, tree trunks, etc.). Classification of pole-like objects is not as successful as classification of basic objects. Typical methods applicable to classification of pole-like objects have been studied from the given references but the methods themselves have not been practically tested. These methods are summarized in Tab.1. Every approach has its specific limitations and needs certain improvements. The common property is that for classification based on mobile laser scanning only space coordinates are often being used. In comparison with that, airborne laser scanning also relies on reflectivity data. The approach presented in this article combines space coordinates of scanned points and reflectivity value for classification of point cloud. The main idea is to expand common classification of pole-like objects based on space coordinates for mobile laser scanning.

Method	Limitations
Brenner,	Focused on rods only without
2009 [7]	associated structure
Golovinskiy,	Does not work reliably if different
2009 [8]	types of objects are to be detected
Lehtomäki,	Requires a scanning trace in a point
2010 [9]	cloud
Yokoyanna,	Requires correctly segmented points
2011 [10]	
El Halawany,	Requires more than one method and
2011 [11]	needs additional information for points
	classification
Pu, 2011 [12]	Does not work well for thick objects
	such as trees

Tab. 1. Comparison of methods for classification of pole-like objects

2. CREATING A POINT CLOUD

Mobile measurement platform contains a 360° range 2D laser scanner (scanning range can be up to 200 m and accuracy of distance measurement is ±1cm) measuring the distance between the scanner head and the object surface and a very accurate navigation system able to determine the current position. This connects two different but complementary position and navigation systems - the Global Position System (GPS) with an active Omnistar correction and the Inertial Navigation System (INS) containing 3 accelerometers and 3 gyroscopes. The GPS accuracy is about 1 meter. By combining both of them we can determine the position with higher accuracy (about 10 cm) and reliability than by using both pieces of equipment separately. There are also inevitable devices like power supply, data storage and other devices used in different topics within the project. The frame of the mobile measurement platform is made up by an aluminum profile with small wheels allowing it to move and execute measurements in the university campus by foot (Fig. 1), thus enabling practical confirmation of a theoretical measurement approach.



Fig. 1. Mobile measurement platform on the road

Average movement speed is 5 km/h and power supply holding time about one hour. Both of devices work independently so the synchronization is not possible. We designed an approach to combine the device data. Data are recorded into the central unit during the measurement. The amount of data is too huge to be processed online; therefore the next phase is offline processing of the data. The algorithm for creating 3D points cloud from 2D profile was presented recently [13]. There are Euler angles for basic rotations and GPS coordinates used for point cloud calculation. The processing contains steps such as extraction, calculation and combination of data (Fig. 2).



Fig. 2. Block diagram of data processing

Experimental measurements were executed in the university parking lot. They were focused on confirmation algorithms of data processing. After calculation of captured data point clouds of the university campus were created (Fig.3).



Fig. 3. Top view of the scanned area in the university campus; about one miloin points

Point clouds from different location should be combined thanks to accurate position information. Visualized points represent road surface, buildings and other objects of the scanned environment.

3. ANALYSIS OF REFLECTIVITY

Besides the distance measurement, the used 2D scanner allows measurement of the reflectivity of reflected laser beam. The signal received from a perfectly reflective white surface meets the definition of 100 % return remission. As a result of this, the reflectivity of the lightreflecting surface (mirrors, reflectors) is more than 100 %. Most of the surfaces scatter the laser beams in all directions. Thus the reflectivity value depends on the structure, color and distance of the object's surface. Bright surfaces reflect laser beams better than dark surfaces and can be detected at greater distances. Some energy of laser beam is lost on very coarse (rough) surface due to scattered rays and thus decreases the range of scanning.

Perpendicular impact on object surface returns maximum of energy back into the scanner. If the beam is incident at an angle, it will cause the corresponding loss of energy and reduce the range of the scanning. Objects smaller than the diameter of the laser beam cannot reflect all the energy of laser beam. Even the seemingly smooth surfaces are bumpy compared with laser beam diameter. The following section describes the analysis of factors which, according to our measurements, influence the value of the reflectivity of the reflect beam the most. Experimental measurements were aimed at a separate analysis of each factor with the largest impact on suppression of other factors. However, each of these factors influences the reflectivity during the ordinary measurements simultaneously.

Distance

The object distance was being continuously increased while the object had a constant surface structure, color and angle of impact in order to determine the dependence between distance and the reflectivity. The results of experimental measurements show that the change in reflectivity remains approximately the same when working with the same distance and surfaces of different colors. However, the total reflectivity depends on the given color.

Color and surface of object

The difference between reflectivity of bright and dark surface is about 20 % (Fig. 4); wavelength of this laser is 905 nm.



Fig. 4. An example of the reflection on a white wall; a black base with a white stripe

Significant difference was recorded in shiny stainless sheet where the reflectivity value exceeded 100 % for perpendicular impact; however, the reflectivity was rapidly decreasing at further impact angles other than perpendicular (Fig. 5). Reflectivity is greatly influenced by the angle under which the beam impinges on the surface and surface structure itself.



Fig. 5. An example of the reflection on a white wall; a polished stainless steel

Angle of impact

As indicated in the previous section, the structure of the surface of the object which the laser beam is incident to significantly influences the measured reflectivity values. When the surface irregularities are greater than the diameter of the incident laser beam, the reflection occurs directly on them and thus the anticipated angle of incidence changes in comparison with smooth surface. If the texture and the roughness are comparable to the diameter of the incident beam, it is not possible to determine the angle at which the light hits the surface, accidental variance occurs. Based on the sequences of reflectivity values it is possible to determine the stability of the structure of the object surface.

4. CLASIFICATION OF OBJECTS

Several classification methods come into consideration [14], based on requirements and aims the 3D model is intended for. The obtained point cloud contains information on positions of the scanned points but does not carry any information as to combination of points which assemble the given objects. The developed application should satisfy the needs of intelligent transport systems which is why the objects within its environment are examined, i.e. road transport surfaces, traffic signs (both vertical and horizontal), crash barriers, building facades and vegetation. There are presently several approaches to classification of objects based on point clouds. Generally, information on position of the object processed out of spatial coordinates is used. This approach is suitable for determination of object whose position towards of the scanner will remain unchanged during scanning. Based on the information on position of the scanned points the surface of road and partly also building facades can be determined in this way.

The classification of point clouds presented in this article uses the intensity value of the reflected beam as complementary information as well. Classification of objects takes place gradually (Fig. 6) beginning with objects with the most remarkable point representation and unambiguity.



Fig. 6. A concept of the proposed three-stage classification algorithm

The points which have already been classified are not used in further classification process anymore which reduces complicatedness of the calculations. Application of complementary reflectivity information proved to be particularly helpful when distinguishing between a tree trunk and a vertical traffic sign pole.

Horizontal Objects - Road Surface

Among all the objects in question, the road surface is as a rule distinguished by horizontal character and the highest numerousness of points representing it. This fact can be applied to histogram of the scanned profile expressing the number of the points on the y-axis. The peak of the histogram corresponds with the number of points on one plane, i.e. the road surface. It is possible to classify all the points neighboring the histogram peak in this way. The points representing the surface are extracted into a separate file and are therefore not used during further classification (Fig. 7).



Fig. 7. Extracted points representing road surface (top); a cloud of non-classified points as a result of the 1st stage of processing - after road surface removal (bottom)

Measuring focused on determining the influence of color on the reflectivity value showed that various colors have various reflectivity values. The contrast between dark road surface and white (reflective) color used for horizontal traffic signs will be used for distinguishing between horizontal traffic signs within the extracted point clouds.

Vertical Objects

Vertical objects considered in the environment of roads include building facades, lamp poles, vertical traffic signs as well as tree trunks. These are objects represented by points with presupposed vertical interrelation character.

Building Facades: Similar approach is applied to remaining points within the profile – on the basis of distance values on x-axis a histogram of points is created that enables us to classify the rest of the examined objects. Building facades generally have vertical character with high levels of point frequency in a small interval. If this element is repeated in the same x-coordinate also in several more neighboring scanned profiles, we can identify a continuous vertical plane, i.e. a building façade (Fig. 8). Other points representing non-classified points are extracted into a separate file and used during further classification (Fig. 9).



Fig. 8. Extracted points representing building facades



Fig. 9. A cloud of non-classified points as a result of the 2nd stage processing - after facades extraction

Pole-like Objects: For illustrative purposes, we are comparing scanned profiles (Fig. 10). The highlighted points represent pole-like objects corresponding with a tree trunk and a traffic sign pole.



Fig. 10. Scanned profile with marked rods of traffic signs (above); a marked tree trunk (below)

Considering the centimeter accuracy of laser scanning Time of flight, it is difficult to determine which one the object in question actually is purely based on processing the spatial coordinates. By processing the reflectivity data in dependence on the angle it is not possible to determine the type of surface exactly; however, we can identify an object with the same surface qualities (Fig. 11).



Fig. 11. The reflectivity of scanned points depends on the position of the scanner head; marked reflectivity of road signs (above), marked reflectivity of a tree trunk (below)

This allows unambiguous assignment of points to the objects. Through internal setting (histogram range, Euclidian distance) the algorithm has been adapted to identification and classification of taller objects that are captured in a sufficient range. Narrow rods of traffic signs have been at the testing movement captured only partially. Point coverage has not been sufficient to fulfil conditions for extraction which results from settings of algorithm parameters (Fig. 12). Therefore information about their position and reflectivity is incomplete what makes their classification in real conditions impossible.



Fig. 12. Extracted points representing poles of street lamps

Vegetation

Vegetation is understood as crowns of trees and bushes in the road surroundings. Vegetation is being classified in the final stage where only the points which have not fit in any other classified group remained of the original point cloud. During classification diffusion of reflectivity values caused by different position of leaves is used.

5. CONCLUSIONS

The procedures presented in this paper suggest our approach to mobile laser measuring based on measured data from devices primarily intended for other uses. Using 2D laser scanner and positional navigation required a design of own method of data processing based on 2D profiles assembling, which allows us to calculate the measured data into three dimensional coordinates system.

The 3D model created from a point cloud should be used for intelligent transport systems, because the object recognition is of high significance in this area; as the first step an automatic classification of point cloud was important. Presented classification algorithms were tested on point clouds generated for different road environments. The classified points were divided into files according to object affiliation. Classification of road surface and facades works well for large areal surfaces; incorrect results appear for buildings with complicated structure. In comparison with common classification methods, we were using not only the point coordinates but also the reflectivity value of every scanned point. Reflectivity of point group was helpful during separation of pole-like objects like road signs and tree trunks. The results of classification with reflection value were better than without it. Using reflectivity of points improves the percentage of pole-like objects classification.

Disadvantage of results showed when a set of points representing the given object is not sufficient and problems were identified when the surface was damaged or its color varied. However, this problem is typical for classification methods based on range data processing.

The potential applications where 3D models might be used are in transport domain (autonomous steering, intelligent transport systems) for visualization of various environments such as factories, office buildings, airports, crucial infrastructures etc.

In frame of our future research we intend to combine point clouds with visual information - images obtained from cameras integrated in the mobile measurement platform. This file could be compared with a database where information on GPS localization of vertical traffic signs will be applied.

6. ACKNOWLEDGMENT

This paper is supported by the following project: University Science Park of the University of Zilina (ITMS: 26220220184) supported by the Research&Development Operational Program funded by the European Regional Development Fund.

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Data Mining on Survival Prediction after Chemotherapy for Diffuse Large-B-Cell Lymphoma and Genomics of Metastasis Cancer

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ABSTRACT

This research pertains to the applications of data mining of microarray databases for large-B-cell Lymphoma and metastasis cancer, for which the latter little has been known about the genomic events that regulate the transformation of a tumor into a metastatic phenotype. The experimental results showed us that lymphoma can be predicted with microarray gene expression data by using naïve Bayesian, random forest and SOM algorithms.

1. INTRODUCTION

Microarray technology has found its applications in recent years in many fields of life science. Generally speaking, all the data analysis behind these applications can be characterized into two major categories: (i.) discovery and (ii.) prediction. Discovery is to discover new knowledge, new genes involved in a pathway; prediction is to create predictive models to be used in such areas as toxicology and disease diagnosis. Fundamental to both discovery and prediction is the selection of genes that are differentially expressed (up or down) when comparing the samples of your interest to the control group.

Both discovery and prediction can help make diagnosis in the perspective of the lab research. Microarray analysis should be consistent with the clinical diagnosis. If both of them have the same conclusion, the diagnostic explanation can be accurate with a high probability; but on the other hand, if their conclusions conflict with each other, neither of them can be useful. In this paper, we use data mining techniques to build prediction models using microarray expression data. After that, we further check with the clinical gene signatures in order to find out if the significant genes that can be used to make prediction models for a particular disease, such as lymphoma, are in gene signature which is built based on clinical predictors, such as international prognostic index (IPI).

2. RELATED WORK

The authors Lu and Segall have performed many previous studies on applications of data mining to microarray databases as evidenced by references Lu and Segall [((2011), [14]), ((2011), [16])] for application of statistical quality control of microarray gene expression, Lu et al. [((2013), [16]), ((2013), [17])] for comparison of data mining methods on microarray gene expression data on cancer, and Lu et al. ((2013), [18]) as a poster of preliminary research of this paper. Segall ((2006), [23]) was one of the first publications in the area of data mining of microarray databases for biotechnology. Segall [((2005), [24]), (2005), [25]) performed data mining of environmental factors on plants. Segall and Pierce [(2009)[26], (2009)[27]] discussed data mining of leukemia cell microarrays and Segall and Pierce [(2009)[28]) extended these using self-organized maps (SOM). Segall and ((2007)[29], (2006)[30], (2008)[31]) Zhang performed data mining for human lung cancer and forest cover data.

Wright et al. ((2003), [34]) used Bayes' rule to classify diffuse large B cell lymphoma (DLBCL) biopsy samples into two gene expression subgroups based on data obtained from spotted cDNA microarrays. They next used this predictor to discover these subgroups within a second set of DLBCL biopsies that had been profiled by using oligonucleotide microarrays. They identified the germinal center B-like (GCB) and activated Bcell like (ABC) DLBCL subgroups that have significantly different 5-yr survival rates after multiagent chemotherapy (62% vs. 26%; p=0.0051), in accordance with the analysis of other DLBCL cohorts.

Wright and Simon ((2003), [35]) proposed a model that can be used to draw gene variances

from an inverse gamma distribution and estimate parameters afterwards. The motivation of their work is that DLBCL dataset has limited samples that makes estimation difficult since variance estimates made on a gene by gene basis will have few degree of freedom and the assumptions that all genes share equal variance is unlikely to be true. This model results in a test statistic that is a minor variation of those used in standard linear models and has more power than standard tests to pick up large changes in expression and does not increase the rate of false positives.

Ein-Dor et al. ((2005), [9]) performed research into the overlap genes of microarray expression data in order to find out whether the different results of the same genes are because of different technologies, or because of different patients and different types of analyses. They used a single method to experiment on a breast cancer microarray dataset. The result set of the genes are not unique which is strongly influenced by the subset of patients used for gene selection.

Colomo et al. ((2003), [6]) concluded that microarray gene expression profiling is associated with particular clinicopathological features but is not essential to predicting outcome in DLBCL patients.

Ross et al. ((2003), [22]) demonstrated that expression profiling of leukemic blasts can accurately identify all of the known prognostic subtypes. By analyzing the leukemic blasts microarray gene samples, the newly identified subtype discriminating genes are novel markers for those not identified in previous study. The newly selected genes are highly ranked as class discriminators that have not yet been used and should be used in clinical trials.

Hans et al. ((2004), [11]) divided diffuse large-Bcell lymphoma into prognostically important subgroups with germinal center B-cell like, activated B-cell like and type 3 gene expression profiles using a cDNA microarray of the created tissue microarray blocks. They concluded that immunostains can be used to determine the GCB and non-GCB subtypes of DLBCL and predict survival similar to the cDNA microarray.

3. BACKGROUND 3.1 Microarray Profiling

For two-color microarray experiments, as shown in Figure 1, one must decide what the most appropriate comparison is to be made for each array of hybridization. The simplest comparisons can be separated into four general classes, such as direct comparison, reference design, balanced block design and loop design. In many ways, direct comparisons are the simplest conceptually; they are used when two distinct classes of experimental samples are to be compared, such as a treated sample and its untreated control. On each array, representatives of the two classes are paired and co-hybridized together such that the relative expression levels are measured directly on each array. The choice of appropriate pairing depends on the experimental question under study. For example, one can pair diseased and normal tissue from the same patient or randomly select animals from mutual and wildtype groups. The strategy to collect data for any given case is influenced by a wide range of factors, including the availability of samples, the quantity of RNA that can be obtained, the size of the study, and the logistical constraints in the laboratory.

For each gene, the process begins with defining an expression vector that represents its location in expression space. In this view of gene expression, each hybridization represents a separate distinct axis in space, and the log2(ratio) measured for that gene in that particular hybridization represents its geometric coordinate. In this way, expression data can be represented in m-dimensional expression space. where m is the number of hybridizations and where each gene expression vector is represented as a single point in that space. It should be noted that one could use a similar approach to representing each hybridization assay using a sample vector consisting of the expression values for each gene; these define a sample space whose dimension is equal to the number of genes assayed in each array.



Figure 1: Illustration of a microarray containing thousands of "spots" of genomic data [2]

3.2 Data Mining using Self-Organizing Maps (SOM) on Microarray Gene Expressions

We refer the reader to a complete discussion of Self-Organizing Maps (SOM) as was presented in our WMSCI 2012 paper Lu and Segall ((2012), [15]) and we are thus providing below a brief discussion. Self-Organizing Maps (SOM) belong to competitive neural networks. Competitive learning is an adaptive process in which neurons in a neural network are sensitive to different input categories, sets of samples in a specific domain of the input space. ([1], [7], [8], [10], [12], [13], [19], [20], [21], [32]) According to Wikipedia ((2013)[33]), a selforganizing map consists of components called nodes or neurons. Associated with each node is a weight vector of the same dimension as the input data vectors and a position in the map space. The Self-Organizing Map describes a mapping from a higher dimensional input space to a lower dimensional space. The procedure for placing a vector from data space onto the map is to find the node with the closest (smallest distance metric) weight vector to the data space vector.

A Self-Organizing Map (SOM) consists of two layers as shown in figure 2. Suppose that we have a set of n-dimensional vectors. The first layer of SOMs is the input data which transfer to the second layer. The second layer has a number of neurons that are chosen arbitrarily and can be used to represent the feature space.



Figure 2: SOMs Architecture

On the second layer, each neuron has the same dimension as the input neuron from the first layer. First of all, weights of the neurons on the second layer are set randomly. During the training process, they have their own weights vector and update those during the training process. When an input x arrives from the first layer to the second layer, the neuron that is best able to represent it wins the competition and is allowed to learn it even better. Moreover, not only the winning neuron but also its neighbors on the lattice are allowed to learn.

4. LYMPHOMA MICROARRAY GENE EXPRESSION PROFILE CLUSTERING 4.1 Background

After multi-agent chemotherapy, two subgroups of diffuse large-B-cell lymphoma had different germinal-center B-cell-like outcomes. The subgroup expressed genes that are characteristic of normal germinal-center B cell were associated with a good outcome. Whereas the activated Bcell-like subgroup expressed genes that are characteristic of activated blood B-cells were associated with a poor outcome. The international prognostic index (IPI) was generally used to stratify patients for therapeutic trials, but, its accuracy is not good enough.

In this paper, we explain how to check patients' genes with microarrays and analyze for genetic abnormalities; find patients with distinctive gene expression profiles; and construct molecular predictors by using genes. There were 160 patients in the training set and 80 patients in the test set. The following three gene expression subgroups were identified: (i.) germinal center Bcell-like, (ii.) activated B-cell-like, and (iii.) type 3 diffuse large-B-cell lymphoma, but only the germinal center B-cell-like subgroup contributed to the lymphoma. Seventeen genes were used to construct a predictor of the survival after chemotherapy. Patients of the germinal center Bcell-like subgroup had the highest survival rate. We compared the accuracy of this predictor with that of the international prognostic index. By using data mining methods to analyze microarray gene expression data, we can create predictors for the survival after chemotherapy.

4.2 Experiments

For hierarchical clustering, we used correlation as similarity measure. We did complete linkage clustering of the 74 significant genes which distinguished between germinal center B-cell lymphoma and activated B-cell lymphoma, as shown in figure 3 and did single linkage clustering of all genes as shown in figure 4. Output describing the meaning of each node on the hierarchical structure of the 74 significant genes has also been generated.



Figure 3: Visualization of 7399 genes from 275 patient cases



Figure 4: The hierarchical structure of the 74 significant genes which can distinguish germinal center B-cell lymphoma and activated B-cell lymphoma.

5. MICROARRAY GENE EXPRESSION DATA CLASSIFICATION

We used 240 patient cases and 522 significant genes chosen by using t-test (p< 0.01). Three data mining algorithms are tested, which are Naïve Bavesian model, Random Forest model and Self-Organizing Map (SOM). The experimental results are listed below where TP=True Positive and FP=False Positive. Т

	TP Rate	FP Rate	Precision	Recall	F-Meature	ROC Area	Class
Naive Bayesian	0.993	0	1	0.993	0.996	1	0
	1	0.007	0.99	1	0.995	0.996	1
Random Forest	1	0.01	0.993	1	0.996	1	1
	0.99	0	1	0.99	0.995	1	1
SOM	0.949	0.01	0.992	0.949	0.97	0.97	0
	0.99	0.051	0.935	0.99	0.962	0.97	1

Evaluation Measurement	Naive Bayesian	Random Forest	SOM
Correctly Classified Instances	99.58%	99.58%	96.67%
Incorrectly Classified Instances	0.42%	0.42%	3.33%
Kappa statistic	0.9915	0.9915	0.9323
Mean absolute error	0.0042	0.1255	0.0628
Root mean squared error	0.0645	0.1504	0.1772
Relative absolute error	0.85%	25.67%	12.85%
Root relative squared error	13.06%	30.42%	35.85%
Total Number of Instances	240	240	240

Table 2: Statistics of Three Data Mining Models

Figure 5: Comparison of the precision and recall on naïve Bayesian, random forest and SOM models

Data Analysis on Micorarray Lymphoma Gene Expression Data with 522 Genes from 240 Patient Cases 1.02 1 Precision of Death 0.98 percentage Precision of Survival 0.96 Recall of Death 0.94 Recall of Survival 0.92 0.9 Random Forest SOM Naive Bayesian

Data Mining Model



Gene Signature	Number of Genes	Number of Microarray Features	Percentage of Microarray Features in Signature	PValue
Germinal- Center-B	151	4	2.65%	0.01
Lymph-Node	357	13	3.64%	0.01
MHC-Class II	37	22	59.46%	0.01
Proliferation	1333	288	21.61%	0.01

With the microarray significant features that we used to make predicator, we checked with the gene signatures for germinal center B-cell signature, lymph-node signature, MHC-Class II signature and proliferation signature, that we used to make predictions in clinical practice. We can see 59.46% MHC-Class Il signature characteristics are microarray significant features, 21.61% proliferation signature characteristics are microarray significant features, 3.64% lymph-Node signature characteristics are microarray significant features, and 2.65% germinal center B-cell signature characteristics are microarray significant features, that means microarray gene expression profiling and particular clinic pathological features are consistent. Therefore, we can use microarray gene expression profiling alone to theoretically predict lymphoma.

6. DATA MINING OF MICROARRAY DATA FOR METASTASIS CANCER 6.1 Background

The data sets selected from the Broad Institute are two of those posted as available with unrestricted access as one of the web links posted on the web page of the Broad Institute Cancer Program Data Sets ((2008),[4]) and is that which is related to the "Genomic analysis of metastasis reveals an essential role for RhoC" research project of the Broad Institute. The selected data base for this research was used by Clark et al. ((2000),[5]) to illustrate the essential role of RhoC that is a member of thee Rho family of proteins that promote reorganization of the cytoskeleton and regulate cell shape, attachment, Figure 6 from Wikepedia and motility. ((2008),[33]) provides an illustration of RhoC also known as "Ras homolog gene family, member C". Wikepedia According to ((2008),[33]), overexpression of this gene is associated with tumor cell proliferation and metastasis.



Figure 6: RhoC Genome [Source: Wikipedia ((2013),[33])

6.2 Experiments

The databases utilized for this research in the applications of data mining are those used in Clark et al. ((2000),[5]) as collected at affiliated sites of the Broad Institute ((2008),[3]). These data was collected from human A375 tumor cells, and successive metastases M1, M2 and M3 that were isolated, expanded in tissue culture, and re-introduced into host mice which exhibited more pulmonary metastases. That is M2 data is that collected from those injected with A375M1 cells, and M3 data is that collected from those injected with A375M2 cells. These constitute the first set of data for which data mining had been subjected.

The second data collection was for metastatic A375SM cells grown as a subcutaneous tumor to indicate that the expression of genes is truly intrinsic to the subjected metastatic cells. It was noted by the Broad Institute ((2008,[4]) that the tumor microenvironment may help to regulate the absolute level of gene expression.

The following figures were conducted using SAS Enterprise Miner version 5 using the data from Broad Institute ((2008),[4]) for A375 and A375SM tumor cells of metastasis cancer. Figure 7 and Figure 9 are the self-organized maps showing their frequency and normalized means, Figures 8 and 10 for the cluster proximities, and Tables 4 and 5 are the statistics from the SOM data mining. As can be seen from Figures 8 and 10, that the cluster proximities are generally much smaller of A375SM cells grown as a subcutaneous tumor. Figure 9 shows that the normalized means for A375SM are fewer but more intervals of frequency than those of Figure 6 for A375. Table 4 for A375 cells shows that the magnitude of the statistics are larger for those of the same segments of those of Table 5 for A375SM, indicating that the genes of the subcutaneous tumor are substantially and uniquely different from those of A375 cells of metastasis cancer.



Figure 7: Self-Organized Map for A375 tumor cells



Figure 8: Clusters Proximities for A375 tumor cells

SEGMNT_1	Frequency	Root-Mean-Square S	Maximum Distance	Nearest Clus	Distance to Nearest Cluster
1	38	50.618659564	295.71869062	9	122.06120183
2	384	18.115234257	147.34248162	18	37.293219634
3	438	22.353532824	116.1175645	10	19.027497333
4	108	38.887504055	168,7091303	12	41.20100371
5	21	90.905340615	337.06956136	20	123.87636225
6	1		1017.9779283	7	333.15978477
7	176	22,795447446	95.254048226	19	30.993036631
8	781	15.931357436	109.98190024	21	1665.3200531
9	298	27.592381989	128.43830736	2	77.747080094
10	52	50.128459918	160.91940164	3	19.027497333
11	7	90.203033772	221.68922191	3	49.72095851
12	1		0	- 4	41.20100371
13	37	64.641527109	256.93960745	5	198.77475684
14	286	21.222788789	141.88531045	6	352,46705515
15	108	32,540400553	133.01900475	6	382,43704795
16	19	88.208352497	278.44837693	8	3467.0669165
17	19	218.01654175	633.22604101	1	173.40553175
18	9	366.37933186	988.10920955	2	37.293219634
19	5	225.901601	554.42719991	7	30.993036631
20	69	30.644449215	110.95094926	12	79.760695081
21	19	52.958128298	144.13107685	13	303.10076918
22	8	132.06171898	392.82207636	14	576.61638941
23	10	272.85554447	679.514007	15	1281.4978591
24	4	792.11078771	1599.6692236	8	1677.4541574

Table 4: Statistics from SOM Data Mining for A375 Tumor Cells



Figure 9: Self-Organizing Maps for A375SM tumor cells



Figure 10: Cluster Proximities for A375SM Tumor Cells

_SEGMNT_1	Frequency of Cluster	Root-Mean-Square Stan	Maximum Distance	Nearest Cluster	Distance to Nearest Cluster
1	553	10.298474184	62.197277163	11	15.82975899
2	155	22.080329029	133.90265227	11	28.584094769
3	20	37.488857994	101.25173371	22	61.280406425
4	3	121.15417175	178.26634256	13	92,602219008
5	15	189.83780044	472.22522515	23	5.6084063275
6	5	660.19845501	1543.749332	15	264,58333519
7	123	16.018964504	72,484463074	16	554 54045439
8	506	12.514063861	56.312248956	17	1002.9333333
9	67	23.911996614	68.402362664	18	1165.1333333
10	8	76.971875662	147.69716695	21	32.135329779
11	6	121.54697309	218.09070488	1	15.82975899
12	6	244.61984111	477.99532489	20	33.675013545
13	36	27.839563033	74.262505702	4	92.602219008
14	343	11.416311377	60.37264235	23	16.353186939
15	226	15.007620811	77.124195496	24	182.20454567
16	11	32.825987488	59.963241055	7	554.54045439
17	9	91.597473886	184.3985552	16	987.46615841
18	8	114.86918025	273.37359968	6	1028.3333335
19	17	62,902293515	187.43197151	10	93 59957527
20	82	17.474843191	56.350885131	1	18.804962896
21	557	10.261943113	70.179097723	1	17.809210281
22	107	21.20125702	83.162852249	12	53.498549052
23	20	43.830339768	165.41179674	5	5.6084069275
24	15	65.807113525	148.62051601	15	182 20454567
abla	5. Stati	istics from	MO2 a	Data	Mining of

Table 5: Statistics from SOM Data Mining of A375SM Tumor Cells

7. CONCLUSIONS

This paper discussed an open issue in Microarray gene expression application. For the lymphoma study two hierarchical structures of microarray gene expression data were built with 7399 genes and 74 significant genes, that visualized the characteristics of the microarray gene expression profiles. We used naïve Bayesian model, random forest model and self organizing maps (SOM) to predict lymphoma with microarray gene expression profile from 240 patients. The experimental results showed us that lymphoma can be predicted with microarray gene expression data by using naïve Bayesian, random forest and SOM algorithms. We further compared the difference between clinic pathological features and microarray features by using gene signatures for Germinal center B-cell lymphoma, lymph-node lymphoma, like proliferation lymphoma and MHC-Class II lymphoma. We can conclude that, since clinical features and microarray features are associated with each other, the predictions from both clinic pathological features and microarray gene features are consistent. For the metastasis cancer study, we concluded that data mining of the microarrays using SOM was effective in distinguishing the uniqueness of the genes of the subcutaneous tumors as illustrated by the statistics from the segments in Tables 4 and 5, cluster proximities of Figures 8 and 10, and Self-Organizing Maps (SOM) of Figures 7 and 9.

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Lessons from Game Studies to Enhance Gamification in Education

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ABSTRACT

This paper presents the results of the study of a cohort of college graduate and undergraduate students who participated in playing a Massively Multiplayer Online Role Playing Game (MMORPG) as a gameplay rich with social interaction as well as intellectual and aesthetic features. Statistically significant differences among our participants' perception, sensation seeking, and satisfaction in relation to gameplay features are investigated. Results support the majority of pre-planned hypotheses and show potential important considerations to take into account when developing gamified content for educational applications. Furthermore, the limitation of the data used in this study is presented and future directions to remove the current limitation and proliferate results through qualitative research into players' in-game social interactions.

Keywords: Gamification, Educational Technology, Serious Games, Sensation Seeking, Statistical Significance

1. INTRODUCTION

The present study is situated at the intersection of two conversations. On the one hand, scholars in game studies are researching the burgeoning world of video games, a genre that has penetrated two-thirds of United States households and now constitutes a \$10.5 billion industry [1]. On the other, many educators are exploring pedagogical uses of "serious games" [2] and even prospects for Gaming Across the Curriculum [3], guided by Gee's [4] dictum that "games are potentially particularly good places where people can learn to situate meanings through embodied experiences in a complex semiotic domain and meditate on the process." We believe *motivation* may be a fruitful concept for connecting these conversations and discovering beneficial lessons.

Game studies scholars have given much attention to the question of why people play video games and, in fact, have developed typologies [5] and scales [6] to gauge players' motivations. Drawing from these two conversations may help answer questions that are fundamental to each. For educators, the question is: What would motivate students to play serious games? For game designers, the question is: What motivates players to learn the game?

This paper presents initial findings of a large-scale study of several factors that might have a significant impact on why different groups of people participate in playing video games. Our goal is to find common factors that contribute to human enjoyment, satisfaction, and continued interest in playing video/computer games. Such factors could, we believe, potentially be utilized in developing effective educational games. Looking further ahead, we argue the concept of motivation may offer a bridge to exploring not only individual in-game learning but, ultimately, in-game *social* learning. Vygotsky [7] famously held that "human learning presupposes a specific social nature" so that students are "capable of doing much more in collective activity." Motivation and egoinvolvement are recognized by many disciplines, from psychology to communication studies, as keys to social interaction—vital factors in explaining, for example, how people manage their identities and relationships [8], process messages and change attitudes [9], and make social judgments [10]. Such an investigation will ultimately require, as Ward [11] advocated, a new view that game worlds are "not simply as artifacts of the 'real' world but [are] emerging societies in their own rights."

2. LITERATURE REVIEW

Research on the pedagogical uses of computerized games is largely clustered within two literatures. One is the literature of education and technology. The other is found in rhetoric and composition studies, a discipline that has long been open to "reading" visual domains as "texts" and seeing in these domains spaces for composing rhetorical claims.

Juul [12] addressed the fundamental question—what is a game?—by holding that a game must have rules and variable outcomes which are quantifiable as positive or negative; and that players must expend effort and then experience real-life attachment to and consequences from the outcome. Liebman [13] further suggested that games can be used four ways in education: as vehicles to convey course content; as "texts" that students "read" and analyze through gameplay; as media in which students create their own games; and as an overall approach to pedagogy that incorporates "game-like motivational systems" into course and assignment design.

While the literature in composition studies focuses on the latter three methods—games as "texts" [14], as media for student compositions [15], and as an approach to course design [3]—the education and technology literature centers on use of games to convey course material.

For example, researchers in [16] conducted a mixedmethods study with education major university students. Participants were able to detect embedded learning skills within the games and found the element of motivation important. However, while motivation was not found as a sufficient reason to use games in classroom, teachers found positive responses and peer modeling to be good factors in using game-based technology to deliver course contents.

A 'Deal or No Deal' game was used in [17] in an

introductory statistics course with the goal of entertaining students' understanding of the expected learning outcomes from the course. This alternative activity proves to enable instructors to introduce multiple concepts while efficiently assessing students learning and retention of the materials. Furthermore, repeated play of the game with which the students are familiar benefits students without making the activity tedious as perceived by students performing such tasks with traditional paper and pencil methods.

As part of a larger project financed by the Social Sciences and Humanities Research Council of Canada (SSHRC) from 2008-11, researchers in [18] "examined the impact of an online educational game on cognitive learning". Starting from the popular board game Parcheesi, an online game was created for a senior secondary school health education program. In comparing the subscale and total scores between males and females, no significant differences were found. This confirms that males and females can learn equally well in this setting.

Teoh in [19] examined the potential of simulation using Second Life (SL) in teacher education. It is worth noticing that simulations could be particularly relevant for special education teachers with students who have autism, Down's syndrome, or ADHD —to help pre-service teachers identify and be more empathic toward inclusive teaching in their future classrooms [20]. Simulations such as SL provide a rich platform for learning and exploration that could be used as an extra credit option, a supplementary tool, or an enhancement to teaching because it is hands-on, visual, experiential, individualized, adaptable, and customable; all principles of effective learning that parallel the simulated environment. In addition, SL has also led the way to other simulations development, such as Open Simulator [21], Open Cobalt [22], Kaneva [23], and Open Wonderland [24].

Means to enhance learning outcomes from playing serious games through the use of scripted collaboration in the game play are examined in [25]. As suggested in [25], "Gameplay for complex learning inherently is complex, and development requires expertise from both domain experts, pedagogical designers, text writers and software developers, [26] and [27]".

The work conducted in [28] presents a simple interactive toolkit to deliver assignment contents to a class of biology students. This work showed that while an easy to use game could benefit students to interact with their coursework in a convenient, and efficient way, a successfully gamified content should take into account ways of communicating with the audience in such a manner that the course content is not overwhelmed by the pervasiveness of the game features. Based on our investigation of the literature we are taking the next step of analyzing what factors play important roles in drawing different groups of population to engage with the contents.

We initiated a large-scale study of several factors which might have a significant impact on why different groups of people participate in playing video games. Our goal is to find common factors contributing to human enjoyment, satisfaction, and continued interest in playing. Such factors could potentially be utilized in developing group-specific or group-agnostic games to deliver educational materials and to improve participation and enjoyment while delivering needed services. Our initial findings of the study are presented here.

3. GAME CHOICE

The market based categorization of game genres in the current state of video games defines products into loosely organized categories which stem from similarities, in form, to prior well known releases [29]. In [29], the following genres are investigated, and we based our examination of a proper gameplay for our study based on this classification:

- **Simulation:** games are effectively "soft real-time simulations" [30] in that, a subset of real world is approximated and mathematically modelled while interaction is achieved by acquiring user input and producing human recognizable output. However, this genre specifically refers to the category of games that target sports and other real-life simulations such as dynamics of cities and communities.
- **Strategy:** divided into two categories of Real Time (RTS) and Turn Based (TBS), this genre targets player's ability to approach a complicated scenario by strategizing solutions to achieve a desirable endgame by combining aggressive, semi-aggressive, and diplomatic means. Perhaps this genre is the least of all game genres concerned with cinematic and visual effects, but one of the most difficult for producing Artificial Intelligence (AI) agents.
- Action: as the name suggests, this genre is the most performative [29], and require the player's physical and mental ability to coordinate effectively his/her sensory input with the mapping of actions available through the game's User Interface (UI). This genre is further categorized into Frist Person Shooters (FPS) and Third Person Shooters (TPS).
- Role-playing: closely tied to the literary genre of fantasy [29], this genre gives the player control over their alternate self in the game by presenting a myriad of potential character transformations. Placed within the subtext of a specific culture, or the development of a certain community spirit, combined with the potential complexity of the contextualization of such transformative characteristics and roles could make this genre of gameplay a target rich environment for a large number of human-oriented applications, in education, cultural accommodation, community organizations, etc. With the development of accessible and affordable internet connectivity, the RPG genre has taken a drastic turn in terms of accessibility and availability. Apperley postulates in [29] that, "Massively Multiplayer Online Role Playing Games (MMORPGs) blur the boundaries between games and community completely", thus "MMORPGs should be conceptualized as a convergent technology."

Based on the above categorizations of the video/computer games, and with the goal of finding suitable mediums for gamifying educational content, we selected a Massively Multiplayer Role Playing Online Game (MMORPG) called the Lord of The Rings Online [31] as the target game for this study. LOTRO is produced by Turbine Inc. and Warner Bros. Entertainment Inc.

Gameplay

In LOTRO players take the role of a character from four races; Man, Elf, Hobbit, or Dwarf. Each player can take a specialty from the nine designated classes, Burglar, Captain, Champion, Guardian, Hunter, Lore Master, Minstrel, Rune Keeper, and Warden. Some of the classes are available to all races (Minstrel, Guardian, and Hunter), while others are limited to a subset of the races, e.g. Rune Keepers are playable by Dwarves and Elves while Captain is only playable by the race of Men.

Players will be deployed to the middle-earth on one of the available game servers with two located in Russia; Fornost and Mirkwood, and all others located in North America [32]. Once in game, players will have the option of completing "Epic quests" designed as a part of the main story, or non-story, "Regional", "Raid", "Class", and "Fellowship" quests.

Game Selection Rationale

As a part of this study, we investigate such components of digital gameplay as character development, physical and fantastic settings, gameplay, visual and aesthetic components of the gameplay, as well as the social aspects. Our study is focused on finding features that are perceived commonly within or differently between different groups of participants, with the goal of developing guidelines to effectively design interactive gamified educational material.

As such, LOTRO will be a suitable medium to engage students in a social setting with the goal of performing specific tasks which require critical thinking, problem solving, social interaction, and other competencies that an educational setting targets. Furthermore, players who engage in MMORPGs such as LOTRO will help us understand what aspects of this genre draws them to play the game and what components of sensation seeking are most important for this target population.

4. RESEARCH METHOD

About 50 participants were recruited among students at the University of Houston-Victoria and were tasked to play the Lord of the Rings Online TM, over short, medium, and long durations of time.

Participants

The participants in the study were 36 male and 14 female undergraduate (72%) and graduate (28%) students ranging in age from 18 to 59. Sixty percent of the participants were 18-25, 14% were 25-30, 18% were 30-39, 6% were 40-49, and 2% were 50-59. The sample was diverse with 10% African American, 4% Asian, 28% Hispanic, and 58% Caucasian. Fig. 1 shows a visual breakdown of the participants' gender (a), and age (b), classification.





Materials and Procedure

Students participated in the study as part of computer science research project. Participants completed a 54-item game characteristics survey based on game characteristics identified by Wood et al. in [33] and by Yee et al. in [34]. Participants also completed the 18-item Gaming Motivation Scale (GAMS) [35]. The GAMS is comprised of six subscales of 3-items each - Intrinsic motivation: desire to perform an activity for itself, Integrated regulation: engaging in an activity out of choice that is now a coherent part of the organization of self, Identified regulation: behavior emitted out of choice based on its perceived meaning or its relation to personal goals, Introjected regulation: regulation of behavior through internal pressures like anxiety and guilt which implies partial internalization, External regulation: corresponds to extrinsic motivation, and Amotivation: similar to learned helplessness [35]. Research indicates that the GAMS has adequate levels of validity and reliability [35]. The game characteristics survey contained a 6-point Likert scale from "not important at all" to "very important" for each question and the GAMS contained 7-point Likert scale from "very strongly agree" to "I do not agree at all" for each question.

Research Design

The research design implemented in this study was quasiexperimental. The quasi-independent variables were gender, age partition: 18-25 vs. Over 25, and degree: undergraduate vs. graduate. The dependent variables were apriori (prior) pre-panned comparison of survey characteristic items and GAMS items as well as GAMS subscales excluding the Amotivation Scale which was missing an item when participants completed the GAMS. A priori planned comparisons were made using one-way independentmeasures analyses of variance (ANOVAs).

Research Hypotheses

Prior to the study, there were 8 apriori pre-planned comparisons anticipating statistically significant differences, and 4 apriori pre-planned comparisons anticipating no statistically significant differences.

- H1: There will be a statistically significant difference by gender on the question "How important to you is physical feedback in a game?" because males and females may respond to physical feedback differently with males more favorable to physical feedback or activities.
- H2: There will be a statistically significant difference by gender on the question "How important to you is shooting enemies (targets, etc.) in a game?" because males seem to gravitate more toward aggression or violence than females.
- H3: There will be a statistically significant difference by gender on the question "How important to you is character development over time in features such as dexterity, strength, and intelligence?" because character development may be more important to one gender or the other.
- H4: There will be a statistically significant difference by gender on the question "How important to you are fantasy settings in a game?" because one gender may spend more time imagining than the other.
- H5: There will be a statistically significant difference by gender on the question "How important to you is

different endings (ending options) in a game?" because novelty may be more important to one gender than the other.

- H6: There will be a statistically significant difference by age group (18-25 vs. Over 25) on the question "I play computer (video) games because it is an extension of me." since younger participants have grown up with pervasive computer video games.
- H7: There will be a statistically significant difference by degree (undergraduate vs. graduate) on the question "I play computer (video) games because it is an integral part of my life." since undergraduates are likely to have more free time than graduate students.
- H8: There will be a statistically significant difference by degree (undergraduate vs. graduate) on the question I play computer video games because it is an extension of me." since undergraduates are younger and grew up with computer games.
- H9: There will be a statistically significant difference by degree (undergraduate vs. graduate) on the question "How important to you are sophisticated Artificial intelligence (AI) in a game?" because undergraduates rely more on the ability of the game non-player characters to assist and compete.
- H10:There will be a statistically significant difference by gender on the question "How important to you is building alliances in a game?" because females appear to be more social and relationship-oriented than males.
- H11:There will <u>not</u> be a statistically significant difference by gender, degree, or age group on the question "How important to you are collecting things (e.g. objects, keys, chalices, components) in a game?" because collecting is a universal attribute for gaming participants.
- H12:There will <u>not</u> be a statistically significant difference by gender, degree, or age group on the question "How important to you is multiplayer communication in a game?"
- H13:There will be a statistically significant difference by gender, age or degree on the GAMS subscales because there were differences by gender, age, and degree on some individual GAMS questions.

Results

We present the results of this study in two categories; i.e. descriptive statistics and the Analysis of H1-H13 Hypotheses.

1) Univariate Analyses for Hypotheses H1 through H12

Female participants scored significantly higher (M = 4.62, SD = .65) than male participants (M = 3.44, SD = .96), F (1, 45) = 16.46, p < .001, ηp^2 = .27 on the question "How important to you is physical feedback in a game?"

Female participants scored significantly higher (M = 4.62, SD = .77) than males (M = 3.65, SD = 1.12), F (1, 45) = 8.12, p < .007, $\eta p^2 = .15$ on the question "How important to you is shooting enemies, (targets, etc.) in a game?"

Female participants scored significantly higher (M = 4.92, SD = .49) than male participants (M = 4.24, SD = 1.05), F (1, 45) = 5.13, p < .03, $\eta p^2 = .10$ on the question "How

important to you is character development over time in features such as dexterity, strength, and intelligence?"

Female participants scored significantly higher (M = 4.54, SD = .78) than males (M = 3.79, SD = 1.00), F (1, 45) = 5.75, p < .02, $np^2 = .02$ on the question "How important to you are fantasy settings in a game?"

Female participants scored significantly higher (M = 4.46, SD = .78) than male participants (M = 3.29, SD =1.19), F (1, 45)=10.62, p<.002, ηp^2 = .19 on the question "How important to you is different endings (ending options) in a game?"

The 18-25 age group (M = 5.18, SD = 1.27) scored significantly higher than the Over 25 age group (M = 4.20, SD = 1.79), F (1, 45) = 4.86, p < .03, $\eta p^2 = .01$ on the question "I play computer (video) games because it is an extension of me."

Undergraduates scored significantly higher (M = 5.27, SD = 1.18) than graduate students (M = 5.27, SD = 3.57), F (1, 45) = 5.47, p < .024, $\eta p^2 = .11$ on the question "I play computer (video) because it is an integral part of my life."

Undergraduates scored significantly higher (M = 5.27, SD = 1.18) than graduate students (M = 3.57, SD = 1.79), F (1, 45) = 14.89, p < .001, $\eta p^2 = .25$ on the question "I play computer (video) games because it is an extension of me."

There was no statistically significant difference by degree on the question "How important to you are sophisticated Artificial Intelligence (AI) in a game?", F(1,45)=.22, p=.64.

There was no statistically significant difference by gender on the question "How important to you is building alliances in a game?", F(1, 45) = 1.94, p = .17.

There was no statistically significant difference by gender [F (1, 45) = 4.0, p = .052)], degree [(F 1, 45) = .27, p = .60], or age group [(F1, 45) = 1.87, p = .18] on the question "How important to you are collecting things (e.g. objects, keys, chalices, components) in a game?"

There was no statistically significant difference by gender [F(1, 45) = .14, p = .70], or degree [F(1, 45) = 2.90, p = .09], but there was a statistically significant difference by age group with the 18- 25 age group scoring higher (M = 4.48, SD = .75) than the Over 25 age group (M = 3.75, SD = 1.21) on the question "How important to you is multiplayer communication in a game?"

2) Multivariate Analysis for Hypothesis H13

There was no statistically significant difference by gender or age, but there was a statistically significant difference by degree on the five subscales of the GAMS, F (5, 36) = 2.71, p = .03, ηp^2 = .27. Undergraduate participants scored significantly higher (M = 13.90, SD = 4.16) than graduate participants (M = 9.64, SD = 4.97) on the Integrated regulation GAMS subscale, F (1, 45) = 13.41, p < .001, ηp^2 = .25. Undergraduates also scored significantly higher (M = 13.82, SD = 3.82) than graduates (M = 10.93, SD = 3.93) on the Identified regulation GAMS subscale, F (1, 45) = 7.45, p < .009, ηp^2 = .16. Lastly, undergraduates scored significantly higher (M = 8.36, SD = 4.07) on the Introjected regulation GAMS subscale, F (1, 45) = 5.19, p< .028, ηp^2 = .11.



Fig. 2. Game Characteristics and Inventory questions. These questions are categorized into Social Interaction, Education Interaction, Functionality, Gameplay and Aesthetics.

Tab	le 1. Game characteristics questions relevant to our study
No.	Question
Q1	How important to you is multiplayer communication in a game?
Q2	How important to you is multiplayer option in a game?
Q3	How important to you is solving puzzles in a game?
Q4	How important to you is fulfilling a quest in a game?
Q5	How important to you is skill development in a game?
Q6	How important to you are skill levels in a game?
Q7	How important to you is character development over time in features such as dexterity, strength, and intelligence in a game?
Q8	How important to you is it that a game is based on a story?
Q9	How important to you is rapid absorption in a game?
Q10	How important to you is collecting things in a game?
Q11	How important to you is sophisticated AI in game?
Q12	How important to you is rapid advancement of player in a game?
Q13	How important to you are sound and graphics settings in a game?
Q14	How important to you is the ability of the player to customize the
Q15	actual physical properties of a character in a game? How important to you are high quality realistic graphics in a game?
Q16	How important to you are cartoon-style graphics in a game?

3) Descriptive Statistics

Fig. 2 presents the descriptive statistics from a number of significant questions taken from game characteristics survey. The questions are categorized into Social Interaction (Q.1-2), Intellectual Interaction (Q. 3-7), Mediation (Q. 8-9), Gameplay Dynamics (Q. 10-12), and Aesthetics (Q. 13-16) and shown in Table 1.

We combined the "Extremely Important" and "Somewhat Important" answers as Important, the "Somewhat Unimportant" and "No Important at All" answers as Unimportant, and the "Neutral" and "I don't know" answers as Neutral for clarity (Fig. 2).

5. DISCUSSION

In this study we investigated apriori pre-planned comparisons on several features of gameplay and their perceived importance by several groups of participants. Results supported our anticipated outcomes for H3-H13 hypotheses. This will be quite beneficial for the developers of game content targeting the studied population groups in helping them craft the game content to cater to the target population's satisfaction and needs.

There were two hypotheses (H1 and H2) with results contrary to our expectations for pre-planned comparisons. We had anticipated that males would score significantly higher on the questions of "How important to you is physical feedback in a game?" and "How important to you is shooting enemies (targets, etc.) in a game?" than female participants. However, female participants scored significantly higher than male participants on both of these questions. We can attribute these results to either the limitation of our current data explained below, to the reversal of gender roles in roleplaying virtual environments, or to an unknown factor which needs more investigation and study.

As shown in the descriptive statistics of our study on game inventory questions (Table 1 and Fig. 2) all five categories of Gameplay, Aesthetics, Mediation, Social Interaction, and Intellectual Interaction are perceived as important features of a game if it were to be viewed favorably by the target population. This will be quite important in developing game content for applications in education as maintaining the interest of the target population could be essential in the success of the delivery of educational content.

Limitation

A limitation of the study was an unequal number of male (72%) and female (28%) participants. As such, some of the findings in our preliminary data, such as those evaluated for H1 and H2 hypotheses may change as we increase the size of our sample size and the scope of the project.

6. CONCLUSIONS AND FUTURE WORK

This paper presented our preliminary data and results of a study which investigates gameplay factors that impact immersion and satisfaction perception of video/computer games on a target student population. Our goal is to identify contributing features in drawing students to participate in the gameplay and to establish guidelines in effectively developing gamified educational content.

A significant future direction for our research is to study the contents of the participants' interaction within the game with other players as well as the Non Player Characters (NPCs). We will be specifically performing interaction process analysis as well as comparing socioemotional with task-oriented communications, quantitatively. Furthermore, we will plan to perform ethnography and discourse analysis to investigate the development of communities and cultures in game, qualitatively, to establish guidelines for development of successful gamified educational contents.

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Utilization of Human factors Intervention Matrix(HFIX) to Develop Aviation Safety Management Strategy

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1. Introduction

Abstract

This study applied Human Factors Intervention Matrix (HFIX) framework and Analytic Hierarchy Process (AHP) to develop errors intervention strategy. Our AHP human questionnaire, designed based on the 31 incident scenarios that were taken place between 2009 and 2011 and included 72 safety recommendations to reduce specific human errors, was distributed to commercial airlines related personnel and was completed by eight managers and eleven pilots of commercial airlines and eight officers of Taiwan Aviation Safety Council (ASC). The results specified that each approach in HFIX framework possesses its unique characteristics under consideration of different criteria. This study has demonstrated that the HFIX framework can apply to the reduction of human errors from five different approaches. The study also suggests that each commercial airline selects appropriate intervention strategies in accordance with its own demands and resource limitations, and AHP can serve as a tool to assist its decision makers to evaluate their diversified strategies with different criteria in developing aviation safety management strategies.

Keywords: Human Errors Intervention, Human Factors Intervention Matrix, Analytic Hierarchy Process, Commercial Airline, Pilot According to an analysis of global safety data involving commercial air transport aircraft with a maximum certificated take-off mass of more than 2,250 kilograms, the accident rates are between 3.5ppm and 4.5ppm during 2002 and 2011[1]. Human errors not only do not decent but also become the major cause of aviation mishaps[2]. Safety is a non-negotiable characteristic in the aviation industry. Keeping safety flight is the utmost goal and diversifying tools are being continually developed to satisfy the goal[3]. As can be seen on the first column in Figure-1, safety management system (SMS) is a structured method to identify, delineate, communicate, control, eliminate and search the risk. However, a commercial airline rarely has sufficient resources to implement all the human errors intervention strategies simultaneously. Hence, a rationalization process is critical to take place in order to evaluate the importance and likely success of the strategies[4].

Wiegmann and Shappell [5] proposed a safety management process, as illustrated in Figure-1, that integrates Human Factors Analysis and Classification System (HFACS), Human Factors Intervention Matrix (HFIX), and ergonomic theory to assist corporations to remedy human errors. The HFACS is the most popular framework for investigating human errors in flight operations. It addresses human errors at four levels[6]:





- Level one, unsafe acts of operators active failures, is the level at which the majority of accident investigations are focused. Failures at this level can be classified into two categories: errors and violations.
- Level two, preconditions for unsafe acts latent/active failures, addresses the latent failures within the causal sequence of events as well as the more obvious active failures. It also describes the substandard conditions of operators and the substandard practices that they perform.
- Level three, unsafe supervision latent failures, traces the causal chain of events producing unsafe acts up to the level of the front-line supervisors.
- 4. Level four, organizational influences latent failures, describes the contributions of the most elusive of these latent failures, fallible decisions of upper levels of management which directly affect supervisory practices, as well as the conditions and actions of front-line operators.

The HFIX can be applied to develop intervention strategies when causation of occurrence was identified[7]. HFIX matrix pits the level-1 of HFACS (unsafe acts) against the five different safety approaches and the five evaluating criteria. The unsafe acts were described as operators commit errors or violation that includes decision errors, skill-based errors, perceptual errors and violations. These unsafe acts can be mitigated by the following five approaches: organizational/ administrative, human/ crew, technology /engineering, task/ mission and operational/ physical environment approach. Additionally, the strategies can be evaluated by criteria of feasibility, acceptability, cost, effectiveness and sustainability. The HFIX framework is described diagrammatically in Figure-2.



Figure-2 Human Factors Intervention Matrix (HFIX) framework

Analytic Hierarchy Process (AHP) is one of the most widely used multiple criteria decision-making tools and has been extensively applied in different fields such as planning, selecting a best alternative, resource allocations resolving conflict, and optimization[8]. Vaidya and Kumar[9] describe the basic steps of AHP methodology as:

- 1. State the problem.
- Broaden the objectives of the problem or consider all actors, objectives and its outcome.
- 3. Identify the criteria that influence the behavior.
- Structure the problem in a hierarchy of different levels constituting goal, criteria, sub-criteria and alternatives.
- 5. Compare each element in the corresponding level and calibrate them on the numerical scale. This requires n(n-1)/2 comparisons, where n is the number of elements with the considerations that diagonal elements are equal or '1' and the other elements will simply be the reciprocals of the earlier comparisons.
- Perform calculations to find the maximum Eigen value, consistency index CI, consistency ratio CR, and normalized values for each criteria/ alternative.
- If the maximum Eigen value, CI, and CR are satisfactory then decision is taken based on the normalized values; else the procedure is repeated till these values lie in a desired range.

2. Method

Material. The data were derived from the narrative description of incident occurring in commercial airlines between 2009 and 2011. The data set comprised of 31 incident reports that included specific causes and 72 safety recommendations from investigators. Our previousstudy has classified these recommendations into five approaches of HFIX framework (organizational/ administrative, human/ crew, technology/ engineering, task mission, and operational/ physical environment) [10] and their readiness for future analyses.

Build the hierarchy. This empirical study used the AHP and HFIX framework to build hierarchy structure, as illustrated in Figure-3.



Evaluation criteria. In order to better evaluate the human factors intervention strategy, HFIX framework proposed five criteria to aid managers for making decisions.

- Feasibility evaluates whether a strategy is liable to be successfulin current situation[11]. Our study adopted factors of logistic capacity, resource allocation, and timing to evaluate feasibility of human errors intervention strategy.
- 2) Acceptability evaluates whether the organization's stakeholders are likely to support the new strategy. The consideration for evaluating acceptability focuses on the return and risk involved. Culture awareness is also required in order to determine the likely acceptance of the strategy by the organization itself.
- Cost examines the tangible and intangible expenses of implementing a strategy. When a corporation carries out human errors intervention strategy, it may incur financial

cost and opportunity cost, and benefits could be emerged, too[12]. Our study hence adapted cost-benefit analysis (CBA) to assess the corporate's program.

- 4) Effectiveness evaluates whether a strategy facilitates to achieve the goal. The goal of implementing human errors intervention strategy includes direct goal, e.g. mitigating human errors, and indirect goal, such as enhancing corporate competition and image. Our study adopted these factors to examine effectiveness of strategy.
- 5) Sustainability evaluates whether a strategy satisfies needs of future stakeholders[13]. Our study considers economic, social and environmental aspects to examine sustainability of a human errors intervention strategy.

3.Research results

Our study adopted AHP to assess the importance(weight) of these intervention approaches on different criteria. The AHP questionnaire that based on scenario of the 31 incidents was completed by eight managers and eleven pilots of commercial airlines and eight officers of Taiwan Aviation Safety Council(ASC). All twenty seven questionnaires passed consistency test based on the respondent's Consistency Index (C.I.) and Consistency ratio (C.R.) values.

The research results are summarized in Table-1. The study found that organizational/ administrative approach had the highest weight value of 0.25 in acceptability, followed by feasibility (0.22) and cost-benefit(0.19). In human/ crew approach, both criteria of feasibility and acceptability got high weight(0.21), followed by effectiveness (0.19). In technology/ engineering approach, weight of effectiveness had the highest value (0.23), followed by sustainability (0.22) and acceptability (0.21). In task/mission approach, both criteria of effectiveness and sustainability got same weight value (0.21), followed by feasibility(0.20). In operational/ physical environment approach, the top three weighting criteria are effectiveness(0.25), sustainability (0.24) and acceptability (0.22).

4. Discussion

Proceedings of The 18th	World Multi-Conference on S	Systemics, Cybernetics and	Informatics (WMSCI 2014)
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		Intervention Approach																		
	(//	Organiz Admin	zationa istrativ	l e		Human /Crew			Technology /Engineering			Task /mission				Operational /Physical Environment				
	М	Р	0	GM	М	Р	0	GM	М	Р	0	GM	М	Р	0	GM	М	Р	0	GM
F	0.22	0.20	0.24	0.22	0.22	0.20	0.20	0.21	0.18	0.17	0.18	0.18	0.21	0.19	0.20	0.20	0.18	0.18	0.17	0.18
A	0.25	0.24	0.25	0.25	0.22	0.19	0.23	0.21	0.22	0.21	0.21	0.21	0.18	0.20	0.18	0.19	0.22	0.19	0.24	0.22
C/B	0.16	0.23	0.18	0.19	0.13	0.14	0.11	0.13	0.08	0.10	0.08	0.09	0.11	0.13	0.15	0.13	0.07	0.10	0.09	0.09
Е	0.20	0.17	0.13	0.16	0.18	0.20	0.18	0.19	0.23	0.22	0.24	0.23	0.19	0.23	0.21	0.21	0.23	0.26	0.25	0.25
S	0.13	0.10	0.18	0.13	0.15	0.18	0.16	0.16	0.23	0.23	0.20	0.22	0.24	0.20	0.19	0.21	0.24	0.25	0.22	0.24
Note1	Note1: F=Feasibility. A=Acceptability. C/B=Cost benefit. E=Effectiveness. S=Sustainability, G.M.=Geometric mean.																			
Note2	lote2: The data in column M, P, O are geometric mean of 8 managers, 11 senior pilots and 8 officers of ASC respectively.																			

The x-axis of HFIX framework comprised five intervention approaches, and each approach possesses unique characteristics under consideration of different criteria.

Organizational/administrative approach. This approach focuses on the way in which the organization and supervisors may need to modify to improve safety[14]. Among the 31 incident reports, investigators suggested several workable recommendations in this approach. The recommendations were, for example, changing managers/ supervisors involvement and oversight/ monitor, paying more concentration on establishing, issuing, modifying and revising the navigation route map, standard operation process(SOP) and regulations, and applying policies of human resource management such as selection, incentive, and promotion, to build upon safety culture of organization. These recommendations got supports from high level managers because they not only can be applied immediately but also require lower cost. Therefore this approach has high weight in acceptability (0.23) and feasibility (0.22), but low weight in sustainability(0.13) when considering influence of interfering conditions.

Human/ crew approach. The recommendations of this approach focus on changing or improving the individual worker or work team to enhance situation awareness and job satisfaction. Among these incident reports of the study, implementable recommendations include holding training course with qualified trainer periodically, enhancing front-line operators situation awareness and professional skill

with scenario-base training, building objective and workable apprising system and reward for safe behavior. The recommendations of human/ crew approach would benefit teamwork and create harmonious collaborations, therefore it has higher weight in criteria of feasibility and acceptability. On the contrary, the weight of cost-benefit is lower because human resource management may incur higher budget.

Technology/ engineering approach. This approach focuses on change or improvement in tools, technology, and job aids to remediate human errors. This study found several implementable suggestions from incident reports, such as improving warning or alarms to increase operators' awareness of abnormal conditions, developing new system to enter into "failsafe" mode when problems occur, scheduling survey new technologies or products in market, and proving adequate spare parts or redundancy and SOP to prevent breakdown or interference during operation. The study found that recommendations of technology/ engineering approach have higher weight in criteria of effectiveness and sustainability, which means that improving performance and stability of equipment can enhance flight safety significantly.

Task/ mission approach. The approach focuses on ways of changing operators' task to reduce errors and improve flight safety. This study found that implementable recommendations may include using checklist or automatic facilities to reduce requirement for human memory, performing double-check with team member to avoid errors occurring in important steps, developing reward system to

reinforce the behaviors of compliance with safe work practices, redesigning procedure and checklist to be clearer or more user-friendly, and rewriting procedure to delete ambiguous or inapplicable safety criteria. Since the recommendations of task/ mission approach can be applied to discipline pilots processing information with efficient method, to modify task to reduce aircrew's work-load and opportunity for error, the approach got higher weight in criteria of effectiveness, sustainability and feasibility, but lower in cost-benefit criterion.

Operational/ physical environment. Recommendations of the approach focus on improving both operational environment (e.g., workspace layout and design) and physical environment (e.g., temperature, lighting and noise). Since these recommendations facilitate improving comfortable of workplace and reducing worker pressure, the approach got higher weight in criteria of effectiveness and sustainability, while the criteria of feasibility and cost-benefit are lower because improving objective is widely and cost is highly.

5.Conclusions

The Human Factors Analysis and Classification System (HFACS), which based on Reason's model of human error[15], describes that active failures associated with the performance of front-line operators in complex systems, and latent failures hat lie dormant within the system that combines with other local factors to breach a system's defaces. Active failures of operators have a direct impact on safety. However, latent failures are spawned in the upper levels of the organization and are related to management and regulatory structures. On the other hand, the HFIX is applied to develop intervention strategy of human errors with five difference approaches and evaluate it with five criteria. Aviation industry is an open system and all commercial airlines operate into a wide range of airports that are not owned by the airlines. Therefore airplane maintenance is often provided by third parties and ATM/ATC is provided by the air traffic service providers of the national authorities of the countries into which they either operate or overfly. As a result the external environment, internal conditions, and corporation goal of the airline should deliberate, when it scheme and select new human errors intervention strategies. Our study found that each approach in HFIX framework possess its unique characteristics under consideration of different criteria, which suggest that commercial airlines select appropriate intervention strategies in accordance with each airline's own demands and resource limitations, and AHP can serve as a tool to assist decision makers to evaluate the diversified strategies in developing aviation safety management strategy with various criteria.

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A Smart Cooperative Learning System

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ABSTRACT

Progress in wireless communications technology and popularization of smart devices has made educational institutes utilize such smart devices as learning tools. However, employing existing communications networks for these smart devices may cause expenses. Wireless network users may be inconvenienced by the loss of communications signals or poor mobile device receptions. In this paper, a smart cooperative learning system that can be used under any communications network environment and provide a sound wireless communications environment without any additional expenses that are caused by using the existing communications networks is proposed. A prototype is designed and practical learning environments of this system are also proposed.

Keywords: Wireless mobile communications, Smart devices, Cooperative learning, Smart learning, Wi-Fi

1. INTRODUCTION

Smart devices, such as smartphones and tablet computers, are often used in educational environments due to recent advances in wireless communications technologies and popularization of smart devices. According to the Korea Communications Commission's report on September, 2012, more than 3,000,000 people are using smartphones or tablet computers.[1] A prototype Smart-School system is being tested in Seojong City, Korea, where the government branch buildings are planned to be located. In this system, students are given tablet computers instead of paper textbooks and electronic student ID's on the tablet computers. In the Smart-School system, students and their parents can get useful information, such as class schedules, counsel information of teachers, and information on the children's school life. Putting such information on the internet, this system will provide education-related services and serve as a service for student's safety.[2]

As a countermeasure of learning by rote's failing results, many education systems that require student's spontaneous learning are being introduced. Development of computer networks and multimedia technology has brought popularization of online education environments that encourage student's unsupervised learning. Especially, e-learning systems that are based on the world-wide-web are popularly being used by online educational institutions because in the systems, students can make the best and infinite use of learning resources. [3,4,5] Students can get lecture materials that are more appropriate to their learning abilities via online learning systems and have discussion based interactive and cooperative classes. Smart devices are suitable for such online interactive learning systems due to their convenient transportability. However, these learning systems may incur inconveniences, such as the consumption of a high level of data that can cause additional costs and frequent disconnections or poor mobile device receptions. Also, most applications for smart devices were developed using existing wireless mobile networks.

In this paper, an independent wireless mobile network environment with the access point (AP) technology of an ad-hoc wireless mobile network is implemented. Using this network environment, a cooperative mobile learning system, that can be used under any communications network environment and does not require any additional expenses, is proposed and a prototype is developed. [6,7]

2. SYSTEM DESIGN

Figure 1 shows the suggested system made of users, one server and many other clients. Cooperative learning in this system is accomplished by the server opening a learning room and preparing lecture materials, and clients entering the room.

2.1 System Structures

The systems for a server and clients in Figure 1 comprise one manager and five modules, as in Figure 2. The Main manager takes charge of the overall system control flow. It creates results of cooperative learning and manages created files, connected users, and other modules.



The Network module manages system communications. It also manages activation and deactivation of Wireless Fidelity (Wi-Fi) and mobile AP's. [8]

The Communication module has a server module and a client module that are implemented using the TCP/IP protocols suite.

A server module and a client module are equipped in an application and the receiver manager is implemented separately to manage messages between the server and the client modules. The Draw module controls drawing and using a variety of components on a screen to develop pictures. The Draw selector of the Draw module manages different drawing properties, and the Draw controller of the Draw module receives drawing events and manages displaying pictures.

The Mycontent module is a module that helps cooperative learning through managing learning materials. That is, it is a module that creates and shares learning materials. The Save module stores and manages learning materials.



Figure 2. System structures

2.2 System Algorithms

Since the system structures in Figure 2 are used for all users, anyone participating cooperative learning can be a server, a host of a learning group, or a client participant of a learning group. As shown in Table 1, when a server creates a cooperative learning room, clients can search for the learning room and join, as in Table 2. At this moment, a server takes the roles as a router of a wireless network and clients connect to the server through Wi-Fi.

Table 1. Server algorithm

start Server module//create room	
while retry=yes	
enter user_name	
if secured_room=yes	
then enter password	
create study room with subject	Call
Mycontents	
retry?	
add my contents	
end	

Table 2. Client algorithm

start Client	module//join
enter user	_name
scan AP	ist and select a room
if secured	l_room=yes
then e	enter password
end	

2.3 Detail Design of System

2.3.1 AP Creation

The server can create a public learning room or a private learning room by assigning a password when creating a mobile network AP in a public or a private mode. Figure 3 shows program codes that create a mobile network AP and the highlighted part is the part where a password is being assigned to create an AP in a private mode. The Korean words in the highlighted part are 'User Input' in English.

Figure 4 shows all the available wireless mobile network AP's that can be connected to smart devices. This system attaches 'SMTM' to the front of the subject that is provided by a server when the server creates a learning room to distinguish the created AP's from other existing commercial AP's (see section 3.1). The highlighted part, 'SMTM[Algorithm Conference]' and 'SMTMmeeting room' in Figure 4 are AP's temporally created by the system.



Figure 3. AP creation

무선 네트워크 연결	~	^
yeonkeune_series5 연결됨	- 11	
SO070VOIP		
SMTM[Algorithm Conference]	*	
SMTMmeeting room	*	1
Byun_	-atl	TI
myLGNet1640		L.
U+zone		
temp		
FLovz_router	*	
samilEC	-anti-	_

Figure 4. Created AP's

2.3.2 AP Activation

After a mobile network AP is created, it must be activated. Figure 5 shows program codes that activate an AP. Wi-Fi that uses the existing network must be deactivated to activate mobile network AP. In Figure 5, the first highlighted program codes deactivate Wi-Fi if it is activated and the second highlighted program codes is the portion where a mobile AP is activated. The first text box of Korean words is a comment to explain these situations. Note that the method 'wmMethod' of the second highlighted part is invoked to activate a mobile network AP, since it cannot be run on the Application Program Interface (API).

After a mobile network AP is activated in this manner, clients can connect to a learning room.



Figure 5. Activating AP's

3. SYSTEM IMPLEMENTATION

Window 7 was used as the development environment, Java se 6 and Android(Minimum SDK Version 2.3 – API 9) were used as system development languages, and Eclipse 3.5.2, ADT10 was used as an development tool.[9,10]

3.1 Learning room creation

Figure 6 shows an example screen where a server creates a learning room.

First, a server must type in a subject to create a learning room. When the server plans to create a learning room in private mode he/she must pick a password, enter it in the password box, and check the checkbook below the 'PASSWORD'.



Figure 6. Learning room creation

A server who creates a learning room in private mode must

notify the password to the clients who wish to participate. 'NEXT' continues to the next step where the server prepares learning materials, and 'CANCEL' cancels the entire process.

3.2 Preparation of learning materials

Figure 7 shows the screen where a server prepares learning materials. 'ADD' brings saved data from the smart device of a server and 'CREATE' finishes creating a learning room and moves to a waiting screen. Data prepared for the current learning materials are shown on the right in Figure 7 in compressed views. These views can be viewed in the format of slideshows and they can be zoomed.



Figure 7. Preparing learning materials

3.3 Waiting screen

Figure 8 shows the screen where the server waits until all participants enter the room. A waiting screen for a client seems similar to Figure 8 but it does not have 'START' on the right. Both a server and clients can view the subject of a learning room and also all participants can be seen in 'USER LIST'.



Figure 8. Waiting for participants

3.4 Cooperative learning

Figures 9 to 12 are captured screens of cooperative learning rooms that were created using the system proposed and implemented in this paper. Many features were included, for instance, drawing a picture on a shared learning material simultaneously. Various icons were placed on the left side of the screen. Using these icons, any participant can edit learning materials prepared by a server.

On the right side of Figure 9, the materials that a server prepared in Figure 7 are located in compressed view. A server can change the current learning material by selecting one of these compressed views. However, clients cannot change a current learning material, even though they can search and view compressed materials.

A server can pause or cease a cooperative learning session and clients can exit a learning room with the permission of a server. When cooperative learning ceases or a client exits a room, learning materials on which participants worked can be saved.



Figure 9. Car designing



Figure 10. Picture drawing



Figure 11. Circuit designing



Figure 12. Fashion designing

4. CONCLUSION

This paper proposed a smart cooperative learning system that provides a sound wireless mobile communications environment without any additional expenses that can be caused by using the existing communications networks. This system can be used as a cooperative learning system under any communication network environments. The proposed system can be used as e-textbooks or cooperative working tools. Therefore, this system can be utilized for educational purpose and business use. Network nodes of the mobile wireless networks that are used to create wireless mobile AP's can leave or join the network freely. Therefore, it is difficult to maintain a wireless mobile network.[11] If the multicasting protocol for high speed wireless mobile communications[12] or the mobility management protocol for many smart mobile terminals [11] is employed in this cooperative learning system to maintain a sound wireless mobile network, the proposed learning system may be a more reliable and useful system.

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Design of Methods for manufacturer and industrial customers relations management from the needs knowledge in after sales context

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ABSTRACT

This study aims at proposing help tools for the management of the relationship between the industrial customers and manufacturing companies. It builds on previous work in creativity, knowledge management and relationships in the context of services on one hand. And it is inspired by the experiment respectively with industrial customers and a manufacturer that offers after sales service, on the other hand.

These studies allow us to establish a conceptual approach to the knowledge of service needs, and develop after sales services, in industries, by organizing and controlling the interventions of interfaces. This is also the place of experimentation with CK theory for improving processes of relationships management between manufacturers – industrial clients within the framework of after-sales services. However, the study leads us to suggest a look at the convergence of ideas, the user profile and the locus of the CK theory use.

Keywords: process, knowledge, relations, after sales services, c-k theory

1. INTRODUCTION

In recent years, several studies point out that services represent a major challenge for our economy, especially a growth opportunity for manufacturing companies [1][2][3]. Some companies realize numerous acquisitions of other companies to approach a model with dominance in services. In addition, they develop various services offers from their know-how to meet the service needs of their customers, and benefit from all durable goods sold.

Despite these efforts in investment, the most important aspect remains the knowledge of a client's needs at a specific moment and the ability to provide solutions in a reasonable time frame. It appears that manufacturing organizations with good service strategies seem to be very limited in number [1].

Our study focuses on "innovation services" to do this, we want to use the C-K methodology of creativity-innovation [7]. Indeed, customer needs can be represented in the expanding space of C "concept" and answers that can be made could be represented in the space of K "knowledge." We shall build the methodology and experiment it on the specific case of the mining industry.

This study will be supported by the construction of an innovative customer approach based in particular on earlier work on industrial relations.

According to Christensen [4], we can achieve innovation in addressing an untapped market with existing solutions or services. This process obeys prior to the establishment of an economic model emerging value proposition. This work therefore combines creativity, innovation methodologies and knowledge management in order to create an innovative customer approach.

2. PROBLEM

Problem Statement

In an industrial market, most companies sell equipment and services to end-users by the intermediate channels, depending on the model in Figure 1. In this configuration, the interactions can be bidirectional. The manufacturer shall maintain a business relationship directly with clients or use intermediaries as channels of access to markets.

One notes the participation of multiple stakeholders in the process of exchange, and it varies depending on the degree of complexity of the equipment to be purchased. And, after the transfer of property, no relational process is clearly established between the manufacturer and the customer, in order to help it to benefit from its material over the long term by offering services.

Although many studies have been conducted on customersupplier relations, it appears that, in the industrial context, the interactions between customers and suppliers, or "moment of truth", strongly depend on the person dedicated to the sale of services [5]. And the intangible nature of services increases the contribution of the person responsible for the services delivery. Besides, access to service opportunities for the manufacturing companies, particularly depends on relationships with customers. Indeed, the literature points out those episodes of trade success lead to close relationships between the customer and the service provider [5].



Figure 1: Model representing the relationships between stakeholders in the transactions of manufactured goods

Our research question in this study is: How can we manage the relationships between customers and manufacturing company from the knowledge of the needs of after-sales services in an industrial context?
Problem Analysis

In the context of after-sales services, according to the link 1 (figure1), the manufacturer tries to establish a connection with the client when seeking opportunities. The initiative of a relationship can start with the customer who is looking for a solution to a problem, referring the link 2. These same steps can take place on either side by the manufacturer following links 5 or 3, or by the client according to links 4 and 6. Could this relational model be appropriated for all service's needs? They may be complexities or different requirements, especially in an industrial context. Sufficient knowledge of the need to time depends on the existing backward linkages. According to the logic of cause and effect, we believe that relational processes must be developed from the knowledge of the services requirements

3. STUDY OBJECTIVE

The purpose of this research is to help develop the potential of after sales services, advocating a method to assist in the modeling of relational processes from knowledge of specific requirements. These are operational approaches able to positively impact the relationship between service providers and after-sales customers, in an industrial context.

Indeed, it appears that the quality of relationships as an indicator of the health and welfare of future sales relationships of long-term services [5]. And Gaiardelli et al. (2007) indicate that the overall performance of services results from the efficiency and coordination of all services network [6].

This study aims to propose a model for building a knowledge base service needs, particularly in the field of after-sales services for one hand; and advocate the process that a manufacturing company could implement in his relationship with his client, on the other hand.

4. HYPOTHESES

Our first hypothesis is: manufacturing companies need a model for knowledge of the market after-sales services.

For the sale of goods, manufacturing companies consider information from the market and the uncertainties related to the sales context. And it has tools to consolidate this knowledge of market potential and production planning.

Some authors advocate the use of methods such as Delphi, regression models, moving averages or exponential smoothing. These methods are based on expert judgments or reflect historical achievements of services. But the peculiarity of aftersales services is that the services are delivered to countable goods and having specific characteristics.

Our second hypothesis is: innovation in services follows a methodology to design processes and relationships based on service needs.

5. METHODOLOGY

We will study this in three ways. We will first make a documentary and bibliographic research. Then we will conduct interviews to gather current knowledge. And finally we try to address the problem by referring to CK theory to make connections between concepts and knowledge.

Literature search

This is to make a review of the literature in order to make a synthesis of previous developments and art in customer relations and service after sale providers. This study would allow us to identify concepts and knowledge able to help build an approach to a purely industrial context.

Interviews

We conducted semi - structured interviews with two samples of target audiences; a total of ten people were interviewed for periods ranging from forty to sixty minutes. The first sample was composed of four people working in the field of after-sales services in a same manufacturing company. And the second sample consisted of six people; two responsible for buying process, two engineering - maintenance leaders and their collaborators; operating in the mining sector. These people work for organizations located respectively in Canada (Montreal, Calgary and Northern Quebec), France (Grenoble) and Africa (Burkina Faso, Guinea and Niger).

These interviews aimed at collecting experiences, understanding the processes and forecasting methods as well as the manufacturing company as in mining industry.

The questions focused mainly on the following points:

- The existence of a knowledge base (or information)

- Methods of forecast annual sales or purchase of maintenance and repair

-The accessibility, the reactivity and the availability of interfaces for delivery of maintenance services and repair

The technique used to record knowledge was that advocated MOKA (Methodology for Knowledge Based Engineering Applications). We used MOKA to gather information and structure.

Analytical method using the C-K theory

The use of creativity tools aims to explore the world of knowledge. These are techniques that allow us to identify new or existing solutions applicable to solving problems of various complexities.

C-K theory is an approach that aims to solve the challenges of creativity and innovation. It helps to think and reason together on the development of skills and products. It is a way of exploring the world of new knowledge through research in the history, use studies, or other functions or auscultation of industrial society [7].

We apply the theory to our case that is a manufacturing company having an interest in the development of activities of after sales services.

Thus, it will enable us to achieve a methodological approach to developing processes to the specific needs of services obtained as a result of segmentation.

LITERATURE REVIEW

After sales services

A service is a performance process or benefit received [8]. It is based on the application of knowledge of a person or machine. Services are intangible [3], and they do not have a quality of externality [9]. They are subject to production and consumption simultaneously. They are perishable and variables. Indeed, the intangibility is expressed by the difficulty of measuring customer performance, and the lack of physical evidence to assess the quality of a service. Perishability is our inability to store service, this results: the importance of time constraints by the actors of the service. The inseparability of production and consumption imply the presence of all stakeholders to take advantage of the service offering [10].

After sales service are seen as services related to the sale of a commodity that can be a good or service [10]. The services offered may be off or extended throughout the life of the product. It includes provision of spare parts, the existence of collateral and offers coverage of certain technical risks and technical assistance subject to a price policy [2].

For clients receiving - It is an opportunity for return on investment over the long term. After sales service provide customers with some assurance about the sustainability of the acquired property and the availability of expertise to support them throughout the life of the equipment. This is the case of the aircraft where the purchaser of a fleet is expected to benefit from the manufacturer's support throughout the operational life of the aircraft.

For goods manufacturers - It is an opportunity to make more profit in the medium to long term and retain its customer for the sale of its future products.

Some device manufacturers, like Apple, which have understood this aspect, pushed further their business models by investing in the development of customers care centres. The service offering remains a major act of differentiation from its competitors. This is the case of Toyota Motor, which became the leader in the luxury segment by offering a range of services and more satisfactory performance Lexus brand vehicles [15].

Segmentation approaches

Segmentation is to split into homogeneous groups according to specific criteria a public or a set of products [10]. This is an effort to make a boundary in a given set. This boundary can be done by various methods by considering the variables that seem most relevant [11]. The goal is to reach entities that are simple and easy to manipulate or explore.

After-sales services have heterogeneous and dispersed characters. The logic of classification may be useful for their prediction. Moreover, the service needs segmentation can be significant homogeneous subsets [11].

Segmentation criteria

Segmentation criteria can be chosen a priori or from a statistical treatment. And the factors affecting the use of these methods are the "number of variables" and "prior knowledge of the public or the problem" [10].

Fitzsimmons et al. (2008) propose the need to categorize services. They adopt an approach to cutting services into three categories: smart services, experience and procedural services.

Intelligent services are extremely complex, and they require high levels of skills able to create and innovate in solving problems. Experience services are services that require a recognized expertise and personalized with little creativity. But they require for stakeholders, a detailed knowledge of the area and capacity for judgment. And services procedure involving well known and standardized, sometimes with a certain level of personalization services. They can be delegated to average skills. The segmentation approach adopted by services is the method selected priori criteria [12]. They use the expertise of resources involved in the performance of services as a single variable.

In our study, knowledge of the needs of after-sales services requires looking at several variables able to inquire about the status of durable goods or services.

In an engineering context, the criteria that guide, very often, the choices of a property, are: application, complexity, environment, life, and the existence of local support. These criteria lead to multiple variables, therefore it will be wise in our study to focus on a static type to allow us to build segments needs.

Clustering

The clustering is a technique for knowledge discovery. It is a process of identifying group similar data in a certain aspect, and construction of a classification (Blood, 2012).

The grouping process generally involves the steps of object and variable selection, standardization of variables, similarity measure, grouping of entities, refinement group, and interpretation of the classification system (Blood, 2012) It advocates the use of the Euclidean distance, the formula is as follows:

$$D(a,b) = \left[\sum_{i=1}^{k} (a_i - b_i)^2\right]^{1/2}$$

D (a, b) indicates the distance between the objects A and B according to i, the number of variables for each object. Indeed, this is justified by the ease of measuring the distance is a function of the magnitude of objects. This is the most important criterion for grouping. And the value of D (a, b) determines the similarity between two objects based on their importance.

Relational processes

A relational process can be defined as the set of actions taken to ensure delivery and the availability of a good or service to a beneficiary; it involves a relationship between two or more entities or people. A relationship exists when there is a series of interactions between two parties, and each party feels connect to the other [14].

Relationships are at the center of the process of value creation. The relationship with the customer is of paramount importance because it is a source of innovation and differentiation on the one hand. And the long-term relationships promote the creation of service offerings tailored to the needs of the client on the other [12].

We believe that a definition of relational processes from requirements definition services could be beneficial to the client and all stakeholders. Given the complexity of some durable goods, the geographical

dispersion of end users, and the variability of the service needs over time, what approaches they could be implemented to build adequate relational process (figure 2)?

6. KNOWLEDGE MANAGEMENT

- MOKA is a methodology and set of tools that have been designed to facilitate the representation of engineering knowledge in structured forms. It allows: a description of the life cycle of an engineering application based on new or modified knowledge, a representation associated with an application using text and graphic knowledge, the representation and mapping knowledge using software [21].

MOKA uses two models of representation that can be prioritized into two levels. These two models are respectively the Informal Model and Formal Model.

In the Informal Model, knowledge is structured into five types, which are illustrations, constraints, activities, rules, and entities. And they are stored in files called ICARE. Each entry contains a particular type of knowledge related to the subject or the subject studied.



Figure 2: Conceptual model for relationship management in after sales services

Formal model is the step of converting the knowledge listed in the ICARE forms in a unified modeling language (UML). This approach aims to prepare a codification knowledge that can be used by an engineering platform based on knowledge (KBE).

- C-K theory: The methodology is based on the existence of two areas: the concepts represented by C, and the space of knowledge that is assigned the letter K. The space C explores concepts pending and new concepts that are exploitable. And K-space is a place of discovery of new knowledge that is used to create value.



Figure 3: framework created by CK theory

Service needs Knowledge

Variables that we can consider for understanding the needs of services are: criticality, reliability, probability of detection, corrosive environment, sustainability, repair of system components, the competence of resources related to the complexity platform.

Each product has external features. So, a service offer must also be based on the characteristics through which the recipient appreciates its value proposition [13].

Variables that establish a pattern of supply of services are the qualifications of persons conducting the service, and the complexity of the system that receives it. Thus, the combination of these variables, knowledge of the hourly volumes of services by type of expertise and periodic usury parts for a given system allows to reach an assessment of the potential income from a platform (figure 4).

Process knowledge

These refer to processes, procedures and interfaces that could exist in various fields such as automotive, mobile or banks, to find alternatives to the construction of a model.

- Interface: Relationships between customers and suppliers are important in a service context. The desire for retaliation customer service failure is low when their relationship is strong [14].

As in engineering, a system is dimensioned according to the customer's specifications; relationships can be so constructed if we know exactly the expectations of the other. In doing so, the services needs knowledge is essential to the design of a relationship. It identifies the work to be done, how to run it, and select stakeholders, therefore the appropriate interfaces (figure 5).

- Process: According to information we obtained from clients, their expectations can be divided into four main stages (figure 6). They focus on meeting a point of locus; the consideration and evaluation of their applications; commercial relations and the execution of their orders. These business combinations are shown below according to their sequence in the "MOKA Modelling Language" (MML) (figure 6) [21].

Implementation of knowledge base system

Space concepts, of CK theory, appealed to notions of quality, reliability, timely availability and customer satisfaction. During the interviews, these are concepts that customers were referring constantly. These concepts should guide us in the definition of a model or a solution.

So, a knowledge base system could be a solution (figure 7). It will provide customers with the following benefits:

- A reliable point of contact, access and timeliness of processing applications
- Assistance continuous
- Hosting data on customer infrastructures
- The drop or elimination of investment and operating costs in data management
 - A knowledge base for manufacturing company.

7. DISCUSSION

The use of CK theory shows that it offers a lot of flexibility. This supports the view designers. They indicate that CK theory can be used in all design situations [7]. However, it is important that we concern a look two aspects in the use of this tool in industrial environment. These aspects are the questions of convergence and the profile of the users.

The convergence: according to the use cases, convergence can be uncertain face a multitude of solutions or alternatives. For lived experiences, it may be due to the intuition of those involved in creativity process. This leads to explore the process that conducts to the convergence towards an idea. The value of a tool lies in its performance more it allows you to achieve results or ideas, some more it will be solicited.

The user profile: the profile of those involved in creativity process with CK theory is not clear. This is a tool that does not require specific profile or number of people required for its use.

The strength of the Delphi method is that it requires a set of experienced people to decide on a topic. Although it cannot be treated as a tool for creativity, it is very often used in processes such experience in project management.

Moreover, the process of "brainstorming" (Osborn, 1935) is still a widely used technique in creative industry. This is explained by the role assigned to the team in addition to the simplicity of the tool. It is the same for the "Six Thinking Hats" method (de Bono, 1985).

The human factor is very crucial in the process of creativity. The relevance of ideas from a process can be linked either to experience or number of participants. CK theory allows wide

opening reflections to explore in all areas in order to identify productive ideas.



Figure 4: Knowledge model predictive service needs

In doing so, we believe that its use should appeal to people who have an open mind or varied experiences. So, should this tool not be used in specialized centers, such as a university or a hub of creativity, where different skills come together? Open mindedness that requires, may it allow a business leader to draw good ideas only with its internal resources?

8. CONCLUSION AND MANAGERIAL IMPLICATIONS

The problem of this study led to two hypotheses focused on the need for knowledge of potential services for manufacturing companies; and innovation in services resulting from a methodology to design the processes and relationships based on service needs. Qualitative studies we conducted, confirmed these assumptions.

Indeed, manufacturing industries generally have very little information on the existing potential for after-sale services. Most of it is in reactive approach rather than a proactive vision. Knowledge needs management of the services market is a challenge for manufacturing companies. The knowledge acquired from the market by the company and its values are important for its growth strategy.

The use of MOKA provides the ability to record knowledge from individuals and non-formal methods, which are the subject of current practices. And CK theory is a method that helps to explore knowledge to identify appropriate methods.

It is useful to complete the convergence of the dimension tool in developing complementary tools that have elaborated filters. This allows the tool to advance a conceptual dimension to an operational dimension.



Figure 5: Positioning of interfaces in a customer relationship-Manufacturing in the context of after sales

Our study also reveals that the client is looking for the shortest path within the after sales services. He wants an available point of contact able to give an answer to his requests. This leads to build a relational process that takes into account the need for easy, fast and reliable accessibility. And it gives the manufacturing company the advantage of knowing the demands of its market, control stakeholders and to have a base of information or knowledge.

9. STUDY LIMITATIONS AND FUTURE RESEARCH ORIENTATIONS

We limit this study to the proposal of a conceptual model and identify an approach to a better understanding of the needs of after-sales service on. And, we suggest an approach that would contribute to the improvement of processes in the field of aftersales services. The validation of our proposals could be the subject of further studies or longitudinal nature of advanced experimentation. Also, it would be interesting to take a look at the development of after-sales services through open innovation approach. Or, one can consider a study of the impact of service innovation about positioning and pattern of structural organization of a manufacturing company



Figure 6: Summary process for a service request

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Figure 7: Representation of the knowledge based system

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The management of Health, Safety and Environment protection in Enterprise processes

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Abstract

The management of Health, Safety and Environment (HSE) protection has an important role both in services and in product companies. The management the HSE means to manage ad-hoc business processes. It is important to manage HSE business processes like the others operating business processes related to its core business.

There are several factors of complexity in the management of HSE: i) there are many laws about HSE and often it is very difficult to keep under control; ii) the business processes that manage the core business of the company are very close to the HSE business processes thus it is difficult to manage correctly every aspects; iii) the information systems that manage the HSE are focused on administrative aspect and not the functional and operating ones.

In this paper, we describe the architecture useful to design and to manage correctly HSE business process. The proposed architecture allows both to have a complete management of the HSE (and not only of the bureaucratic aspect) and to have through the use of knowledge base, a direct link with the description of the law and of the company.

Introduction

The management of the Health, Safety and Environment poses different problems (both related to the respect of the law and to the operative aspects) in the company.

In the Italian legislative system, there are several laws that provide guidelines and constraints about the way to operate. There are national laws and regional agreements, specific legislative decree about the HSE management and several operating procedures.

The legislative system imposes constraints and deadlines for the companies and for their workers. In order to operate in agreement with the Italian regulation, it is important not only to respect the deadlines but to manage well defined business activities using specific applications. These application are useful for the coordination of the activities and for the daily work of the company.

It is necessary to define ad-hoc business processes strictly related to the core business processes. The adhoc business processes must be flexible: they must adapt with simplicity to the organizational changes and to the change of the laws. The problems above described, due to their complexity, are the main subjects of the research project HSEPGEST (Management of Health, Safety, and Environmental Protection in enterprise processes) a PON project funded from European Structural Funds 2007-2013. The project has several industrial partners (each of them are interested to one or more problems exposed above) and several scientific partners (University of Salento, University of Salerno, ...). The main goal of the project is to integrate in a transversal way problems related to different themes using a process oriented approach.

The project starts with a study of the Italian laws in the field of HSE and then all the aspects related to the main goal of the project are collected in a knowledge base. The knowledge base is structured in three sections in order to describe companies, laws and business processes. The project makes a framework of methodological and technological tools to manage the HSE business project according to the information defined in Knowledge Base.

In details, the focus of the University of Salento is about the management of the HSE business process and their execution using tools and techniques already known to the state of the art (BPMN for the design of the business process, Workflow Engine for the execution etc.) but customized in order to solve the problems related to the management of the HSE.

There are several research aspects in the project:

- The use of the ontologies useful for the design of the company and of the law related to the HSEPGEST project.
- The use of the notation to represent Business Processes in order to model business processes starting from the law.
- Integration between business process and ontologies useful to link together the design of business processes and the information coming from law
- Execution of business processes with the introduction of semantic information useful to helps the worker with additional information during the execution of the business process.
- Capability to discover what business processes are affected by a change in the law.
- Use of enterprise 2.0 tools and techniques in order to collect the worker know-how.

An experience similar to that of HSEPGEST project is the SUPER project [1]. The focus of SUPER is not on the HSE problems but is on the integrated management of the business process. SUPER project is less specific with respect to the matters dealt in the HSEPGEST Project. The goal of SUPER is to make the Business Process Management accessible to the business expert; in fact, more often the management of the business process is committed to the IT expert and not to the business expert. SUPER combines the SWS (Semantic Web Service) and the BPM, and the ontologies to describe both business process and domain information. The combination between BPM and SMS allows the automatic management of the business process lifecycle and allow business expert to manage the BPM without IT expert.

In this paper we present the proposed architecture in the research project to manage business process in the HSE. In the next section we present a background about the development of integrated system and then we present a brief overview about the use of ontology in the HSEPGEST project. In the next section we show the architecture of the system and in the conclusions and future works we provide information about how to go forward in the research project.

Background

Beckmerhagen defines the integration of management systems (IMS) as "putting together different functionspecific management systems into a single and more effective IMS" [2]. The research about integrated management systems started at the same time with the publication of Environmental Management System (EMS) in 1996 [3]. Puri proposed a set of guidelines in order to integrate the EMS and Quality management system. Furthermore in the 2006, Jorgensen et al. [4] suggest three levels of integration for a more sustainable IMS: correspondence, coordination and integration. On the basis of this work in the 2008, Jorgensen [16] proposes more sustainable management systems through life cycle management. Meanwhile, using the result of a survey conducted in China, Zeng [17] identifies the internal and the external factors affecting the implementation of IMS. About the factor that affect the creation of a IMS, the research of Wilkinon and Dale [5] are focused on two approaches: i) the first consists in achieving integration including the emergence of documentation through aligned approach and similarities in the standards; ii) the second implements the integrated system through a total quality management approach. Another important work is the one of Labodova [6] who proposes two ways of integration: the first consists of the introduction of individual systems followed by the integration of originally separate ones; the second is an integrating management system based on the risk analysis. Moreover, other academic authors have proposed a variety of methodologies, including Karapetrovic [7] Asif et al. [8] [9]; Lopez-Fresno [10]. Furthermore, there are a number of national standards able to support integration (see, for example SAI Global [11], Dansk Standard [12] AENOR, 2005 [13], BSI [14]) and ISO published a handbook with integration advice, methodology and examples [15].

On the basis of the literatures, during the integration process, the designer of the new system must consider four principal aspects: integration methodology, implementation strategy, level of integration and audit integration. The idea of HSEPGEST approach is focused on the integration methodology and implementation strategy. HSEPGEST wants to overcome the weaknesses of existing systems by proposing a new process-based integration model. The main points of this approach are:

- the integration of the specific knowledge of the three different application domain (health, safety and environmental protection) of the single management system;
- the creation environment able to design specific business process strictly connected with the knowledge base and to execute it taking information by the legacy system.

In the next we explain in detail the architecture and the benefit of this design/execution environment.

The use of the ontology in HSEPGEST in brief

As state in the introduction, the project complexity is remarkable: i) the application domain about health, safety, environmental protection are complex because there are several aspects to take in care; ii) it is important to integrate the different views of the company in only one view; iii) it is important to design the company structure and the company organization in order to translate the laws in business process; iv) there are several actors such as domain experts, company supervisors, business experts etc. that must cooperate in effective way.

Starting from these considerations, it is very useful to develop a knowledge base able to meet together these different types of information. The development of a knowledge base will be supported from the use of ontologies that allows to describe through concepts and ontologies relationship between concepts often complex in reality. The Knowledge base useful for the HSEPGEST project must be made up of three different information:

- Technical/law: these information are related with application domain and are available to the designer in terms of concepts and relationships;
- Company: because the final goal of the project is to develop an integrated management system in the company, it is important to have in the Knowledge base information about roles, responsibility, people etc.
- Processes: business processes are part of the system and of the company knowledge base. The business processes may be the mapping in the company of the information in the knowledge base.

The knowledge made up of these three parts will be shared between all project partners. The benefits coming from the knowledge base are:

- The domain expert has a clear view of the all laws to apply in the company;
- The process designer has a guidelines about laws that will be translated in business process;
- The company's manager has a tool useful to relate executive process to the law.

It is clear that ontologies have a fundamental role for the overall project but ontologies does not make complex the designer work. The designer must have a tool that helps in the use of information in the knowledge base but the complexity of the knowledge base must be hide to the designer.

In this perspective was born the proposed architecture.

HSEPGEST – Process Management System architecture

The proposed architecture is made up of four levels each of them allows to manage one of the four main phases of the HSE information system design and management. These phases cover all the phases of the business process lifecycle from the understanding of the reference domain through the support of the knowledge base (Planning time) to the design of business process (Design time) and to the execution of the business process (Run time). The architecture, also, manage particular unforeseen situations coming from changes in the application domain (Situation time) that may change the normal execution of the business process. In the architecture there is a middleware useful for hiding the complexity of the knowledge base and thus the complexity of the application domain.

In the Planning time, the process designer uses tools present in this level. The system allows the process designer to explore concepts in the knowledge base using the Knowledge Explorer tools. The Knowledge Explorer through the services of KB middleware allows the designer to query the KB in order to discover a specific concept or relationships.

The KB middleware has the task to hide the complexity of the knowledge base making available API to access to the concept in the ontology.

Output of the Knowledge Explorer is the Reference Ontology Context (ROC). The ROC is therefore created by the business expert who "cuts out" the knowledge of interest.

Starting from the ROC the business expert can make both the sub-process template (sub-process template are not executable business process but they can be re-used in executable business process) and complete business process. There is the sub-process Template Editor that allows the process designer to model the sub-process template using the BPMN notation.



Figure 1: System architecture. Planning time & Design time

The KBLink enables the designer to create a semantic connection between the element of the sub-process templates and concepts inside the ROC previously created. This connection is critical to allow the system to intercept all the business processes design involved in any change of information of the Knowledge-base domain. For example, a change of a concept of the knowledge base resulting from a change to the current legislation, affects several all sub-process templates are based on the changed law. The system using the KBlink can report all the sub-process to the business expert who will, if it is necessary, to adjust the sub-process templates previously created.

The output of the sub-process template editor is the subprocess template designed and represented both in semantic format and in a format compatible with the workflow engine. The obtained design together with their ROCs are stored in a repository called the Sub-Process Template Repository and sent to the management modules of knowledge through appropriate methods provided by KB middleware;

At design time, the process designer uses the output of the planning time in order to design business process composing the sub-process templates previously realized. It is clear that the business process design may be related to the knowledge base using the KBlink. In this case, the KBLink enables not only the connection of the business process design with the domain knowledge base but also the connection with domain aspects that enable to define the execution parameters of the business process. These parameters will be available from the business process editor using the KB middleware. An execution parameter is, for example, the names of the people who execute a specific task in a business process.

Despite in the architecture there are two different levels for the design of the business process (one for the subprocess template and another for the complete business process) the two business process design editor will be available from one tool with these characteristics:

- Support to the BPMN 2.0;
- In the design environment there is a palette where to see concepts coming from the ROC;
- Drag & Drop of concepts in the ROC in the tool of design. In this way it is possible to add semantic information in the design of the business process.
- Possibility to add in the property tab of each BPMN element semantic information.

The designer, once completed the design process, establishes if the designed model must be saved as subprocess template or process template. If, the model is saved as sub-process template, it will be saved within the ROC that contains the concepts used by the designer to create the KBlink. The sub-process template will be available for the design of other sub-process template, or will be available to design of executable process. The executable process will contain the references to the ROC.

Of course, the model saved format influence the types of controls that must be performed: if the model is saved as sub-process templates, the system checks only the compliance of the model with the semantics of the BPMN notation. In the case of saving the model ad business process, the system will verify that all the required parameters to make executable the business process are defined.

The architecture, also, provides two other levels that are not represented in the figure as still in an embryonic state. Specifically, it is the Situation time which has the task, based on notifications from the KB Middleware, to identify and suggest to the designer business process compatible with the event generated. Within the architecture is of course also the level of run time that, through a workflow engine will run the business process design defined.

Conclusions and future works

This paper presented a process-oriented architecture useful for managing the complexity of information systems in the field of Health, Safety, Environment Protection. The added value of the proposed architecture is the close connection between the knowledge base (that contains the domain information) and the process design that facilitates the business expert in managing the complexity resulting from the application domain. The architecture allows to manage correctly the correlation between the knowledge base and the design of the process due to the presence of a KB middleware that hides the complexity of KB. The introduction of the ROC enable the business expert to "cut" a portion of the application domain within which to create their own sub-process templates designed as small parts of the process that can be reused in more.

The system that will be implemented starting from architecture will enable the integrated management of HSE processes with other company's business processes allowing to think of the HSE issues not just as a list of deadlines, but also and primarily as a set of activities that must be achieved together in order to achieve specific goals. The next steps of the work will be on the one hand to detail the levels of Situazion Analyzer and Run Time and the other to identify a methodology for design of process-oriented web application contextualized to the management of HSE issues useful to create web applications process oriented and user-centred.

Acknowledge

We want to thank Asperience SPA the main industrial partner of the HSEPGEST project, the University of Salerno and the other scientific and industrial partners for their collaboration and their suggestions in the definition of the presented architecture.

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The negotiation algorithm in the Supply Chain management with multi-agent technology

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ABSTRACT

In supply chain management, improving the efficiency of the overall supply chain is of key interest. Because of market globalization and the advancement of e-commerce the importance of supply chain network is increasing. A supply chain can produce products for multiple markets. Also, an individual company is likely to have only limited visibility of the supply chain structure, which makes it difficult to make future demand estimations, because the pattern of demand propagation through the supply chain depends on the capabilities and strategies of companies along the path from the markets to the company. There will be the conflict among the pursuit of the profit of all members of the SCM. In order to maximize the total profit of the SCM, negotiation among all members is necessary. In this research, we propose to find the best negotiation strategy that makes all members of the SCM satisfied in a simple SCM. The ideas behind the suggested model are negotiation algorithm with an agent and we consider multiple factors that are price, review point and delivery time. We create agents with Java Agent Development Framework and performed the simulation under JADE and Eclipse environment. We have used benefit/cost ratio as a performance measure in order to compare our system with Kasbah system that is a typical system well known to the world. Users create autonomous agents that buy and sell goods on their behalf in the Kasbah system.

Keywords: Supply Chain Management, Multi-Agent, JADE

1. INTRODUCTION

Effective supply chain management (SCM) involves activities to solve the conflicts between demand and supply of resources and services. Negotiations in supply chains may relate to a wide range of details in transaction processes, including the product specification, cost and pricing policy, trade terms and so on. During the negotiation process, the reaction of the negotiation opponents and the dynamics of the market circumstances should be captured. In the supply chain system of manufacturing enterprise based on multi-agent, every agent respectively on behalf of all the different department, organization or enterprises, and driven by interests, and cooperate/e with each other, to complete the process from the purchase of raw materials, processed products, manufacturing, distribution to fin al customer or market. We view negotiation as a bargaining process by which a joint decision is made by two parties. Automated negotiation is a key form of interaction in systems composed of multiple autonomous agents. In this work it is researched that the conflicting preferences over complex multidimensional decision problems involved in the bi-lateral resource allocation negotiation of services. In negotiations, one producer and one consumer have to bargain and come to a mutually acceptable agreement over terms and conditions under

which the producer will execute some activity for the consumer. This paper presented a heuristic negotiation algorithm that is a linear for performing trade-offs in automatic negotiations. The goal of this paper is to demonstrate the value of incorporating one heuristic, the similarity heuristic, in the trade-off decision mechanism for a given set of conditions.

2. NEGOTIATION MODEL

In the supply chain of manufacturing enterprise based on agent, decision making can be supported by any number of heuristics that assist it in searching for potential deals. In the decision model presented in this paper the reasoning process of an agent at each sequence of the negotiation is characterized as meta deliberation over the execution of either a concessionary or a trade-off mechanism or both. The mechanism models iterative concession over the score of a contract based on facts such as the amount of resources consumed in the negotiation, the time remaining until the due date, and the behavior of the negotiation opponent. This paper only discusses the negotiation between purchasing agent and supplier agent

Figure 1 shows the multi-agent based automated negotiation systems.



Fig. 1. multi-agent based automated negotiation systems.

Let i represent the negotiation agent and j be the decision variables under negotiation. Negotiations can range over quantitative or qualitative decision variables. Decision variables are defined over a real domain or defined over a partially ordered set. Each agent has a scoring function V that gives the score it assigns to a value of decision variable j in the range of its acceptable values. Scores are kept in the interval [0,1]. Weight that gives the importance of decision variable j for agent j means the relative importance that agent assigns to each decision variable under negotiation. Both parties have a deadline by when they must complete the negotiation.

In the trade-off negotiation mechanism problem is how to select a contract that is likely to increase the score of the opponent, given that the agent does not know its preferences. To make trade-offs, an agent in negotiation with another agent must be provided with a mechanism to select a set of contracts all of which have the same utility as opponent's previous offer X and to select from this set, a contract X' that agent believes is more preferable to opponent Than X.

3. TRADE OFF MECHANISM

Multi-dimensional decision problems present opportunities for increasing the social profit of the deal through trading off between decision variables. In this paper there is a concessionary strategic mechanism for assigning values to decision nodes. This mechanism fails to explore the space of potentially jointly better solution nodes because it cannot explore different possible value combinations for the local negotiation decision variable. For example, a contract in which the service consumer offers to pay a higher price for a service if it is delivered later. From the service provider's point of view, the former may be acceptable and the latter may not. The suggested model does not allow the agents to explore for such possibilities because it treats each decision variable independently and only allows agents to concede on decision variables. To increase the efficiency of deals, agents need the ability to make-offs between negotiation decision variables. The heuristic is based on the degree of similarity between two consecutive contracts. The agent can use fuzzy similarities to guess the prior probabilities of the other's decisions and then update these prior probabilities in the course of interactions using Bayes rule. From the perspective of the fuzzy set literatures, a fuzzy similarity relation on a set D is a binary function Sim : $D \times D \rightarrow [0,1]$. The method of building similarity functions is to define criteria evaluation functions. Thus, given a criteria evaluation function, h: $D \rightarrow [0,1]$, a natural way to define a similarity function induced by h is to define, $Sim_h =$ $h(x) \leftrightarrow h(y)$, where \leftrightarrow is a fuzzy equivalence operator. For instance, for T(u,v)=max(0, u+v-1), $h(x)\leftrightarrow h(y)=1-|h(x)-h(y)|$, and for T=min, $h(x) \leftrightarrow h(y) = 1$ if h(x)=h(y), and $h(x) \leftrightarrow h(y) = \min(h(x), h(y))$ otherwise.

Given a domain of values D_j , a similarity between two values $x_j, y_j \in D_j$ is defined as $Sim_j(x_j, y_j) = \sum_{1 \le i \le m} \omega_i \cdot (h_i(x_j) \leftrightarrow h_i(y_j))$ where $\sum_{1 \le i \le m} \omega_i = 1$, and $h(x) \leftrightarrow h(y)=1$ -|h(x)-h(y)|. And the similarity between two contracts x and y over the set of decision variables J is defined as $Sim(x, y) = \sum_{j \in J} \omega^a_j \cdot Sim_j(x_j, y_j)$ with $\sum_{j \in J} \omega^a_j = 1$. Given a scoring value θ , the iso-curve at level θ for agent a is defined as $iso_a(\theta) = [x|V^a(x) = \theta]$. The agent needs to select the contract that is most similar to agent b's last offer. A trade-off is defined as: Given an offer, x, from agent a to b, and a subsequent counter offer, y, from agent b to a, with $\theta = V^a(x)$, a trade-off for agent a with respect to y is defined as $trade - off_a(x, y) = arg \max_{z \in iso_a(\theta)} \{Sim(z, y)\}$

The trade-off algorithm is defined over the class of linearly additive utility functions.

The trade-off algorithm is as follows

Step 1) It starts at contract y

Step 2) moves towards the iso-curve associated with x, the agent's last offer.

Step 3) moves to iso-curve is performed sequentially in s steps. Step 4) generating n contracts that have a utility E greater than the contract selected in the last step, y^{j} Step 5) from the generated child contracts, select the one that maximizes the similarity with respect to the opponent's contract v

Fig. 2 shows the part of the algorithm responsible for generating a new trade-off contract.



Fig. 2. Schema of the trade-off algorithm with n=3 and s=3

4. MATHEMATICAL MODEL

Mathematical model for negotiation system can be used as an another approach. Linear programming is used with objective function that maximize the sum of buyer utility and seller utility. Constraints mean that the difference between two player's utility is under predetermined threshold. And decision variables are under the domains.

Objective function: Maximize Z=Buyer Utility + Seller Utility Subject to $|Buyer Utility - Seller Utility| \le threshold$

min. of range $\leq x_j \leq max. of range$ for i = 1,2,..nAfter finding optimal solution, branch and bound enumeration is used for integer decision variable.

5. CASE STUDY

Consider the example of a car-dealer negotiating the purchase of a car. Assume agent a enters the garage and receives the initial proposal x=(green, \$27,000, 80,000 km, 10 weeks) for a deal on buying a car of a given model (over decision variables=[color, price, mileage, delivery]). Agent a responds to this proposal with a counter proposal y=(yellow, \$21,000, 40,000 km, 0 weeks). In order to use trade-off technique domains, weights, value functions and the similarity function for the car dealer should be specified.

 $D^{b}{}_{c} = [yellow, violet, magenta, green, cyan, red]$ $D^{b}{}_{p} = [\$10,000, \$40,000]$ $D^{b}{}_{m} = [5,000 km, 180,000 km]$ $D^{b}{}_{d} = [0 weeks, 16 weeks]$

Value functions are as follows,

$$V_{c}^{b} = [(yellow, 0.5), (violet, 0.2), (magenta, 0.3), (green, 0.8), (cyan, 0.3), (red, 0.8)]$$

$$V_{p}^{b} = \frac{x_{2} - 10,000}{40,000 - 10,000}$$

$$V_{m}^{b} = \frac{x_{3} - 5,000}{180,000 - 5,000}$$

$$V_{d}^{b} = \frac{x_{4}}{16}$$
And weights are $\omega_{c} = 0.1, \omega_{w} = 0.8, \omega_{l} = 0.06, \omega_{v} = 0.04$

Similarity functions are as follows,

For the modeling of similarity for color, three different criteria can be considered. These are warmness, luminosity, and visibility. Given these three criteria, color can be modeled in the following way.

 $\begin{aligned} h_w &= [(\text{yellow}, 0.9), (\text{violet}, 0.1), (\text{magenta}, 0.1), \\ & (\text{green}, 0.3), (\text{cyan}, 0.2), (\text{red}, 0.7)] \\ h_l &= [(\text{yellow}, 0.9), (\text{violet}, 0.3), (\text{magenta}, 0.6), \\ & (\text{green}, 0.6), (\text{cyan}, 0.4), (\text{red}, 0.8)] \end{aligned}$

 $h_v = [(\text{yellow}, 1), (\text{violet}, 0.5), (\text{magenta}, 0.4), (\text{green}, 0.1), (\text{cyan}, 1), (\text{red}, 0.9)]$

Where h_w , h_l , and h_v are the criteria functions. And assume the weights for the different criteria are $\omega_w = 0.7$, $\omega_l = 0.2$, $\omega_v = 0.1$. Then the similarity relations are

$$\begin{split} &Sim_{c}(\text{yellow}, \text{red}) = \omega_{w} \cdot (1 - |h_{w}(\text{yellow}) - h_{w}(\text{red})|) + \\ &\omega_{l} \cdot (1 - |h_{l}(\text{yellow}) - h_{l}(\text{red})|) + \omega_{v} \cdot (1 - |h_{v}(\text{yellow}) - h_{v}(\text{red})|) = 0.7 \cdot 0.8 + 0.2 \cdot 0.9 + 0.1 \cdot 0.9 = 0.83 \\ &Sim_{c}(\text{yellow}, \text{violet}) \\ &= \omega_{w} \cdot (1 - |h_{w}(\text{yellow}) - h_{w}(\text{violet})|) \\ &+ \omega_{l} \cdot (1 - |h_{l}(\text{yellow}) - h_{l}(\text{violet})|) + \omega_{v} \\ &\cdot (1 - |h_{v}(\text{yellow}) - h_{v}(\text{violet})|) \end{split}$$

 $= 0.7 \cdot 0.2 + 0.2 \cdot 0.4 + 0.1 \cdot 0.5 = 0.27$

Similarity for price, mileage, and delivery are modelled as follows,

$$h_{p}(\mathbf{x}) = \begin{cases} 1 - \frac{x_{2}}{40,000} &, x \in [0, 40,000] \\ 0 &, otherwise, \end{cases}$$

$$h_{m}(\mathbf{x}) = \begin{cases} \frac{180,000 - x_{3}}{180,000 - 5,000} &, x \in [5,000, 180,000] \\ 0 &, otherwise \end{cases}$$

$$h_{d}(\mathbf{x}) = \begin{cases} \frac{18 - x_{4}}{18} &, x \in [0, 18] \\ 0 &, otherwise \end{cases}$$

From the car dealer's point of view, contracts x and y have different values;

 $V^{b}(\mathbf{x}) = 0. \ 1 \ \cdot 0.8 + 0.8 \cdot \frac{27,000 - 10,000}{40,000 - 10,000} + 0.06 \cdot \frac{80,000 - 5,000}{180,000 - 5,000} + 0.04 \cdot \frac{10}{16} = 0.5840$ The value of agent a offer is

 $V^{b}(\mathbf{y}) = 0. \ 1 \ \cdot 0.5 + 0.8 \ \cdot \frac{21,000 - 10,000}{40,000 - 10,000} + 0.06 \ \cdot \frac{40,000 - 5,000}{180,000 - 5,000} + 0.04 \ \cdot \frac{0}{16} = 0.3553$

After one more step, three children contracts will be generated. $X_1 = (\text{yellow}, 29,055.38, 44,096.25, 5 \text{ weeks})$ $X_2 = (\text{red}, 26568, 99,017.78, 12 \text{ weeks})$ $X_3 = (\text{violet}, 30,556.51, 258.47, 7 \text{ weeks})$ $V^b(X_1) = V^b(X_2) = V^b(X_3) = 0.5840$

Now, the trade-off algorithm selects the one with highest similarity with respect to the offer made by agent a, that is contract y, using the car dealer's decision variable weights $Sim(y, X_1) = 0.1 \cdot Sim_c(yellow, yellow)$ $+0.8 \cdot Sim_p$ (\$29,055.38 \$21,000) + 0.06 $\cdot Sim_m(40,000km,$ 44,096.25km) + 0.04 $\cdot Sim_d(0 weeks,$ $5 weeks) = 0.1 \cdot 1 + 0.8 \cdot 0.799 +$ $0.06 \cdot 0.977 + 0.04 \cdot 0.722 = 0.8264$ $Sim(y, X_2) = 0.1 \cdot Sim_c(yellow, red)$ $+0.8 \cdot Sim_{p}$ (\$26,568) \$21,000) + 0.06 $\cdot Sim_m(40,000km)$ 99,017.78km) + 0.04 $\cdot Sim_d(0 weeks)$ $12 weeks) = 0.1 \cdot 0.84 + 0.8 \cdot 0.861 +$ $0.06 \cdot 0.663 + 0.04 \cdot 0.333 = 0.8257$ $Sim(y, X_3) = 0.1 \cdot Sim_c(yellow,$ violet)

 $+0.8 \cdot Sim_p(\$30,556.51 \$21,000) + 0.06$ $\cdot Sim_m(40,000km, 258.47km) + 0.04$

 $Sim_d(0 weeks, 7 weeks) = 0.1 \cdot 0.27 + 0.8 \cdot 0.761 + 0.06 \cdot 0.773 + 0.04 \cdot 0.611 = 0.7067$

Given these values, the algorithm would chose X_1 as the tradeoff to customer a.

That is, X' = (yellow, \$ 29,055.38, 44,096.25km, 5 weeks)In order to use trade-off technique domains, weights, value functions and the similarity function for the customer(car buyer) should be specified.

 $\begin{array}{l} D^{a}{}_{c} = [yellow, violet, magenta, green, cyan, red] \\ D^{a}{}_{p} = [\$5,000, \$50,000] \\ D^{a}{}_{m} = [0km, 200,000km] \\ D^{a}{}_{d} = [0 \ weeks, 20 \ weeks] \end{array}$

Value functions are as follows,

$$V^{a}_{c} = [(yellow, 0.5), (violet, 0.2), (magenta, 0.3), (green, 0.8), (cyan, 0.3), (red, 0.8)]$$

$$V^{a}_{p} = \frac{50,000 - x_{2}}{50,000 - 5,000}$$

$$V^{a}_{m} = \frac{200,000 - x_{3}}{200,000}$$

$$V^{a}_{d} = \frac{20 - x_{4}}{20}$$
And weights are $\omega_{c} = 0.2, \omega_{w} = 0.7, \omega_{l} = 0.06, \omega_{n} = 0.000$

And weights are $\omega_c = 0.2$, $\omega_w = 0.7$, $\omega_l = 0.06$, $\omega_v = 0.04$ Similarity functions are as follows,

The modeling of similarity for color is the same as car dealer. Similarity for price, mileage, and delivery are modeled as follows,

$$\begin{split} h_p(\mathbf{x}) &= \begin{cases} 1 - \frac{x_2}{50,000} &, & x \in [0, 50,000] \\ 0 &, & otherwise, \end{cases} \\ h_m(\mathbf{x}) &= \begin{cases} \frac{200,000 - x_3}{200,000} &, & x \in [0, 200,000] \\ 0 &, & otherwise \end{cases} \\ h_d(\mathbf{x}) &= \begin{cases} \frac{20 - x_4}{20} &, & x \in [0, 20] \\ 0 &, & otherwise \end{cases} \end{split}$$

From the car buyer's point of view, contracts x and y have different values;

$$\begin{split} V^{a}(x') &= 0.2 \cdot 0.5 + 0.7 \cdot \frac{50,000 - 29,055.38}{50,000 - 10,000} + 0.06 \cdot \frac{200,000 - 44,096.25}{200,000} + 0.04 \cdot \frac{15}{20} = 0.5026 \\ \hline \text{The value of agent a offer is} \\ V^{a}(y) &= 0.2 \cdot 0.5 + 0.7 \cdot \frac{50,000 - 21,000}{50,000 - 10,000} + 0.06 \cdot \frac{200,000 - 40,000}{200,000} + 0.04 \cdot \frac{20}{20} = 0.6391 \\ \hline \text{After one more step, three children contracts will be generated.} \\ Y_{1} &= (yellow, 21,000, 26,667.04, 2 weeks) \\ Y_{2} &= (yellow, 20,742.86, 26,667.04, 4 weeks) \\ Y_{3} &= (green, 24,021.44, 50,000, 5 weeks) \\ V^{a}(Y_{1}) &= V^{a}(Y_{2}) = V^{a}(Y_{3}) = 0.6391 \\ \hline \text{Now, the trade-off algorithm selects the one with highest similarity with respect to the offer made by agent b, that is contract x', using the car buyer's decision variable weights \\ \hline \text{Sim}_{a}(26,667.04km, 44,096.25km) + 0.04 \\ \cdot Sim_{a}(2 weeks, 5 weeks) = 0.2 \cdot 1 + 0.7 \cdot 0.839 + 0.06 \cdot 0.913 + 0.04 \cdot 0.85 = 0.8761 \\ \hline \text{Sim}(x', Y_{2}) &= 0.2 \cdot Sim_{c}(yellow, yellow) \\ \hline \end{tabular}$$

 $\begin{array}{ll} +0.7 \cdot Sim_p(\$29,055.38 & \$20,742.86) + 0.06 \\ \cdot Sim_m(26,667.04km, & 44,096.25km) + 0.04 \\ \cdot Sim_d(4 weeks, & 5 weeks) = 0.2 \cdot 1 + 0.7 \cdot 0.834 + \\ 0.06 \cdot 0.913 + 0.04 \cdot 0.95 = 0.9313 \\ Sim(x', Y_3) = 0.2 \cdot Sim_c(yellow, green) \\ +0.7 \cdot Sim_p(\$29,055.38 & \$24,021.44) + 0.06 \\ \cdot Sim_m(50,000km, & 44,096.25km) + 0.04 \\ \cdot Sim_d(5 weeks, & 5 weeks) = 0.2 \cdot 0.43 + 0.7 \cdot 0.899 + \\ 0.06 \cdot 0.97 + 0.04 \cdot 1 = 0.9117 \end{array}$

Given these values, the algorithm would chose Y_2 as the tradeoff to customer a.

That is, Y' = (yellow, \$20, 742.86, 26, 667.04km, 4 weeks)These process will be continue until the difference of value function between two successive contracts of agent a and b is less than the predetermined threshold.

Let's think about mathematical modeling. And If the threshold is 0.01 then

Buyer Utility = $0.2 \cdot x_1 + 0.7 \cdot \frac{50,000 - x_2}{50,000 - 5,000} + 0.06 \cdot \frac{200,000 - x_3}{200,000} + 0.04 \cdot \frac{20 - x_4}{20}$ Seller Utility

 $= 0.1 \cdot x_1 + 0.8 \cdot \frac{x_2 - 10,000}{40,000 - 10,000} + 0.06 \cdot \frac{x_3 - 5,000}{180,000 - 5,000} + 0.04 \cdot \frac{x_4}{16}$

Then mathematical model for negotiation is as follows,

Maximize $Z = 0.3x_1 + 0.00001x_2 + 0.0000313x_3 + 0.0125x_4 + 1.13413$

Subject to

 $\begin{array}{l} -0.1x_1 + 0.00005x_2 + 0.000012x_3 \\ +0.1125x_4 - 1.14616 \leq 0.01 \\ 0.1x_1 - 0.00005x_2 - 0.0000012x_3 \\ -0.1125x_4 + 1.14616 \leq 0.01 \\ 0 \leq x_1 \leq 1 \\ 10,000 \leq x_2 \leq 40,000 \\ 5,000 \leq x_3 \leq 180,000 \\ 0 \leq x_4 \leq 16 \end{array}$

The optimal solution with integer value is $x_1 = 0.5$, $x_2 = 24,899$. $x_3 = 35,382$. $x_4 = 3$ That's mean (yellow, \$24,899, 35,382km, 3 weeks) This solution is a litter different from the result of trade-off algorithm.

6. CONCLUSIONS

This paper presented a formal heuristic model with trade-off mechanism that has been the use of fuzzy techniques for the design of negotiation agent architecture. The entity in supply chain of manufacturing enterprise can be abstracted into the independent agent by the application of agent technology. The particular technique adopted was fuzzy similarity in order to cope with the inherent uncertainties in the negotiation process. And empirical evaluation demonstrated the algorithm's effectiveness in generating trade-offs in a range of negotiation contexts.

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Accounting Information Systems and Decision Making

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Keywords: Accounting information systems, decision making, data quality, and management accounting controls.

1. INTRODUCTION

Success in the implementation of the accounting information systems (AIS) / enterprise research planning (ERP) systems is critical to organizations. With the high failure rate of AIS/ERP systems implementation, it is important to study the important factors that impact systems implementation, as well as the links to measurable organizations outcomes. Additionally, regardless of the size of a company, senior executives must pay attention to which management accounting and control (MAC) practices are needed (Duh et al., 2009), the integrity of the processes for collecting the data (Xu et al., 2002), and the impact of the human factors that contributing to the success / failure AIS/ERP systems implementation.

Implementation of AIS/ERP systems is a complicated process, and many factors impact the successful implementation of these systems (Xu et al., 2011). This study is especially important from decision making and managerial accounting perspectives, as the AIS/ERP systems are not merely systems that generate the data from daily operations and reporting; they also are vital tools to provide information for decision making and control. The objective of the study is to answer the following research question:

• Would Success in the Accounting Information (AIS)/ERP Systems Implementation Lead to Confidence in Decisions? With the sub- questions of:

o What are the factors that related to data quality, management accounting controls, and human relations that would have impact on successful AIS/ERP implementation?

o Would the successful implementation of AIS/ERP lead to greater confidence in decisions in organizations?

2. THE RESEARCH FRAMEWORK

This study develops a research framework based on the Technology Acceptance Model (TAM) (Davis, 1989), to shed light on the management accounting controls (MAC), data quality, and human factors' impact on the AIS/ERP implementations. System implementation success was measured with user satisfaction and integration of non-financial and financial measures. Figure 1 shows the research framework of this study.



Figure 1: Research framework of AIS/ERP implementation and confidence in decisions

In the literature, user satisfaction is used to assess systems implementation success (Davis, 1989; Chau, 1996). Additionally, this research proposes that confidence in decisions measures of successful AIS/ERP is the ultimate implementation. The research framework is based on the Technology Acceptance Model (TAM) (Davis, 1989), which has been validated by other researchers, such as Chau (Chau, 1996). According to TAM, system use depends on attitude towards use that is divided into two elements: perceived usefulness and perceived ease of use. Both issues affect user satisfaction. Previous research has attempted to use the extended TAM in the ERP implementation environment (e.g., Amoako-Gyampah and Salam, 2004). Target costing and balance score card are MAC practices that depend on integrating non-financial and financial measures for their success (Hansen and Mowen, 2011), and we plan to assess its use. Next, we discuss the independent variables.

Management Accounting and Control (MAC) Practices: There are many management practices that might have impact on the systems implementation success. This study used the following measures for MAC practices: (1) activity-based costing, (2) cost-volume-profit analysis, (3) budgeting, and (4) responsibility accounting (Duh et al., 2009).

Data Quality Issues: It is essential to understand the data issues to ensure success in implementing AIS/ERP, as low quality data can have a negative impact on the integrity of the information produced from those systems (Xu et al., 2002). Legacy systems created using different functional applications could potentially cause problems when the old data migrates into a new AIS/ERP system. Well researched and tested data quality dimensions is used to measure accuracy, relevance, usefulness, completeness, and up-to-date of information from the systems (Wand and Wang, 1996).

Human Factors: This study is also interested in human factors that can affect the users of the systems, namely, (1) the commitment of the management, and (2) the management leadership style. These factors have been studied extensively in

the management and accounting literatures. In the context of budgeting, studies have shown that budget participation, high commitment and a considerate leadership style lead to better resource allocation (Parker et al., 2010), better coordination between managers as well as higher job performance (Parker and Kyj, 2006; Magner et al., 1996). The study builds on this literature and uses similar scales to measure leadership style in the context of using MAC practices and AIS/ERP implementation.

Confidence in Decisions: AIS/ERP systems provide potential benefits for decision-support (Holsapple, C. W. & Sena, M. P., 2005). It is important to build a positive relationship between the success AIS/ERP implementation with the subsequent realization of decision-support benefits from the AIS/ERP systems. AIS/ERP systems store critical information and knowledge used to make the decisions that drive an organization's performance. They not only provide transactional information, ERP adopters also perceive substantial levels of decision-support characteristics in their ERP systems (Holsapple, C. W. & Sena, M. P., 2003). Decision support systems have been evaluated the outcomes of decision making, and have a crucial impact on the processoriented aspects of decision making. The real-time DSS offers a significant improvement in terms of process-related characteristics (Phillips-Wren, Hahn & Forgionne, 2004). AIS focus on the financial and managerial accounting outcomes, and ERP systems focus on integration of the business process, therefore, this research would investigate whether successful implementation of AIS/ ERP systems would lead to better confidence in decisions.

3. METHODOLOGY

Large scaled cross sectional survey was conducted to collect the data for this research. Constructs and questions of the survey questionnaire were from existing literature of information systems, data quality, accounting, and management fields (Davis, 1989; Chau, 1996; Duh et al., 2009; Parker et al., 2010, Wand and Wang, 1996). The questionnaire had three sections. The first section included question regarding the respondents' experiences with AIS / ERP systems. The second section had three major components: the first one captured critical success factors including the MAC practices, data quality, and human relation issues that would impact the AIS/ERP implementation success; the second component measures for the level of success of AIS/ERP implementation from the user's perspective and the use of non-financial data; and the third component was related to the confidence in decisions. Finally, the last section covered the respondents' demographics information. The target respondents for the survey were users that have had experience with AIS/ERP system; they included accounting, IT, general management and non-management personnel from different type and size of organizations.

Hypotheses and Data Analysis

The following is the plan for hypothesis testing and data analysis. First, confirmatory and exploratory factor analyses will be conducted to ensure the validity of the measurement scales. Second, the following hypotheses will be tested: (1) MAC practices, human factors, and data quality issues will influence AIS/ERP system implementation success which are measured using user satisfaction and the integration of nonfinancial measures, and (2) the AIS/ERP system implementation effectiveness would lead to better decisionmaking. Third, the LISREL software will be used for structured equation modeling, and the fit results will be corroborated with path analysis. The results will be used to validate the research framework proposed in this study. Modifications and adjustments will be made if necessary to the initial research model based on the data analysis results.

4. IMPLICATIONS FOR PRACTICE

Implementation of AIS/ERP systems is a complicated process, with many factors impacting the successful implementation of those systems. Understanding the MAC, data quality, and human factors' impact on the AIS/ERP implementations would help organizations and practitioners to manage this complicated process, and ensure resources are employed in the right places, which would lead to better outcomes. Often, practitioners in the fields feel pressured by top management to complete the implementation with less resources and time, which contribute to a high failure rate of AIS/ERP systems' implementations. This research helps management accountants and IT managers to identify critical successful factors that have most influence on the AIS/ERP implementations, by focusing on those factors that would increase the possibility of the successful implementation of those systems. The research also focuses on the decision support aspect of the systems implementation, using factors related to the decision support such as the confidence in the decisions. It is especially important from managerial accounting perspectives, as the AIS/ERP systems are not merely systems that generate the data from daily operations of financial reporting; it is also a vital tool to provide information for decision making. The result of this research would show what the critical success factors are for their implementation and what influencing MAC practices. Hence, this research would highlight what organizations need to focus on to increase their chances of obtaining the benefits of AIS/ERP systems.

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Informing via Research: Methods, challenges and success when using a multi-disciplinary team and reverse engineering analysis processes to answer a 200 year old question.

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ABSTRACT

The goal of this study was to develop the foundation for the creation of a 21st century spiritual which could be used to mitigate the effects of stress and violence. Using a multi-disciplinary team and basing the work in the music of the antebellum Negro Spiritual (a group of 6000 works), reverse engineering, extensive use of engineering principles and utilization of existing databases was done to aid in the of the neurological analysis and physiological impact of the musical form and development of an applicable theory.

Keywords: Music, Neurology, Physiology, Negro Spiritual, Reverse Engineer

1. INTRODUCTION

This study was stimulated by the fortuitous discovery that some of the methods used in the Emotional Freedom Technique (EFT) to combat Post-Traumatic Stress Disorder (PTSD) are very similar to the musical and worship practices of the historic Black Church of the Deep South of the United States. Emotional Freedom Technique is approved by for use psychologists by the American Psychological Association and is in the process of being defined as an evidencedbased intervention for PTSD.

It was in the South during the antebellum period that enslaved African Americans were subjected to inhumane methods of plantation labor force discipline, methods that included flogging, rape, dismemberment, torture, and continuous mental abuse intended to create cowering subservience and a conviction of personal unworthiness within the logic of the masterslave relationship. Given the nearuniversality of these methods of domination, it would be reasonable to expect that the enslaved population would have exhibited diminished vitality and more of the symptoms of what is now being called PTSD. Folklore left by the slaves conveys their understanding of how they stood up combined under the pressure of undernourishment, overwork and abuse: they said that they sang together, and that it was the singing that strengthened them.

However, the antebellum spiritual used on the plantations has not been in use in the specific form of the period since the Civil War and as of 2010 there were no longer any living survivors of the slave experience. In the 1930s the Smithsonian had collected some slave narratives and some old-time singing, but even those artifacts reflected the passage of time and the change from slavery to freedom as the essential context of the music. Meanwhile, African Americans were leaving the South. In the two Great Migrations of the 20th Century a very large number of African Americans moved to Northern cities and developed worship music more suited to their urban environments. The folkloric rural music began to disappear. By the late

20th Century most of the music still described as the "Negro Spiritual" was actually part of the concert tradition in African American sacred music and consisted of either art songs or choral arrangements performed by classicallytrained musicians. There was also an enduring practice of singing spirituals in the style of conventional Christian hymns in churches and community meetings, and the spiritual was the music of the Civil Rights Movement. By the 1980s, however, gospel music had become the dominant form of music for worship, and the old-time plantation spiritual and its successor music of the small rural black church were on their way to becoming objects of mainly antiquarian interest.

2. PROJECT MISSION

The original mission was to build the spiritual for the 21st century. This intention has guided the inquiry. We did not take the characteristics of the original spiritual as our starting place; rather we took those aspects of contemporary practice that have continued the characteristics of the original spiritual. Those have proven durable over the centuries and are familiar to the potential users of the music to be created.

3. HISTORY AND STRUCTURE OF THE SPIRITUAL

The spiritual arises musically out of three African musical traditions: (1) the work song, a typically call-and-response musical form that utilizes an energizing melody and regularized rhythm in order to control and coordinate the rhythm and tempo of work; (2) traditional praise songs and religious chants, often led by the local Griot; and (3) the "ring-shout," an African form of communal circle dance and song that the slaves adapted to their circumstances. In the Americas, these songs were improvised out of the material of daily life, and included commentary on secular conditions as well as religious content.

Musicologists have also identified a group of characteristics that contribute to an identifiable "Black Aesthetic." The characteristics include group expression often facilitated by call and response structure; improvisation in both music and lyrics, articulated by all participants; downward flowing melodic lines both of the slow, sustained type and the syncopated, uptempo type; rhythmic complexity and regularity often expressed through the use of percussive expression; the incorporation of physical movement, use of oral kineticism, and the use of harmonic, pitch and timbre flexibility.

Then there were the lyrics to the songs. The EFT literature teaches that the substitution of a positive or affirming thought for a negative one can have a transformative effect on an individual's stress response. This is guite evident in the spiritual. The words to the spiritual frequently included Judeo-Christian biblical themes drawn from both the Old and New Testament. Familiarity with the Biblical texts inspired the slaves to cast themselves in the role of the Israelites in the Old Testament stories, to cast the slave owners in the role of Pharaoh, whose attempt to prevent God's liberation of the Israelites was famously and disastrously unsuccessful, and to identify the suffering and resurrected Jesus as their friend and brother. This was an authoritative Christian antidote, from the masters' own religion, to the secular English legal doctrine that the enslaved were chattel property. The enslaved Africans and their descendants later reported that their singing had been the source of their strength, the means of preserving their culture, and the vehicle for expressing their wisdom and their faith that slavery would end.

After slavery ended, the spiritual and the secular motifs within African American folk music tended to separate, with the spiritual going into the emerging black church and the secular evolving into a variety of commercial music, e.g. ragtime, minstrelsy and vaudeville, Tin Pan Alley,

blues, jazz and eventually general popular music. However, the explicitly spiritual aspect of the music has been accorded an exalted place because of its emphasis on liberation, transformation and transcendence and the cultural centrality of the black church. The challenge was to transition from the "lived" experience in historic literature into a theory of the neurological and physical effects of the spiritual based on neuroscience. The result has been to project a portrait of the effects of the folk spiritual as used in the historical small black church that, while not susceptible of validation by clinical trials, is surprisingly consistent with both historic and contemporary reported experience.

4. REVERSE ENGINEERING AND DATA ANALYSIS

Since we were essentially doing a "design recovery", reverse engineering was selected as the process methodology with which to develop the necessary information. Reverse engineering is defined as "the process of taking something apart and analyzing its workings in detail." (Chikofsky and Cross, 1990) Thus, the very first step was to compile an historical record of observations and commentary regarding the spiritual.

We determined there were several types of consistent experiences: the experiences of being "saved" and then baptized, descriptions of the "power of the lord", fellowship as a factor of a strong community and in providing support to individuals, and the sense of community magnified through the church experience. Common in descriptions was the phrase "the sound of your grandmother humming" and the stalwart support of the church being based in the women of the community.

The next step was to define the foundations of the musical structure and its effects and see how they matched historic practice and effects. We identified the following elements in the structure of the music which existed in both time periods: positive spin, looking forward, recognition of cognitive dissonance, affirmation, fellowship, unity of experience and purpose. These elements then underlined and defined the rest of the investigation.

Matching was then done of the stated responses with the neuroscience of the physiological same types of and psychological experiences. Once those areas of the brain were defined, we then searched the literature in the following databases to find neurological research on music that matched the same areas of the brain: PubMed, PsychInfo, Medline, EMBASE, Cochran Reports, and Google Scholar. We looked for studies that included both specific and relevant brain regions and significant empirical methodology. We primarily selected studies that included: MRI, fMRI, PET and EEG with MEG or QEEG analysis. After the basic selection of studies was studies which specifically reviewed. involved the Polyvagal system were also included. From this work an annotated bibliography and theory were developed as the final step.

5. DETAILED EXAMPLE

A detailed example of this process begins with a book written in 1861 Incidents in the Life of a Slave Girl which was published for the author Linda Brent by Harriet Ann Jacobs. After reading the book, relevant sections of the original narrative were selected for further exploration. For example pp 64 "If I ever know of your speaking to him, I will cowhide you both; and if I catch him lurking about my premises, I will shoot him as soon as I would a dog." And page 94 "He sprang upon me like a wolf, and grabbed my arm as if he would have broken it." In conflict with her master Linda had denied him access to her bed short of rapeing her and her master was continuously threatening her with physical violence as a result. He began this systematic abuse when she was 15.

We then looked at the situation with more modern eyes. This is consistent with a

situation of violence against women, where a woman is under the physical control of a man and is regularly threatened and treated with physical violence. Violence like this produces a whole series of stress factors such as increased blood pressure, increased cortosol levels, and nore-epinephrine and epinephrine flooding the body creating a state of hyper vigilance. Next was an examination of current literature to determine stress factors and physiological issues in violence against women who experienced it over a length of time which included a number of years. Searches were done on online medical/psychological databases like the National Library of Science data base PubMed. A search using the string "domestic violence against women" yielded over 1500 peer reviewed published articles. Over 100 articles were selected for detailed review. For example "Intimate partner violence in adult women and its association with major depressive disorder, depressive symptoms, postpartum depression: a systematic review and metaanalysis" was one of the studies explored. (Beydoun et al, 2012) Information from the various articles was then analyzed and synthesized and a list of relevant areas of the brain and body developed. Among those relevant to violence against women are the medial pre-frontal cortex, hippocampus, hypothalamus, frontal lobes and temporal lobes of the brain.

A list of studies were developed which looked at the effects of music on the brain and body. Over 3000 studies using such strings as "music", "music therapy", "music and neurology" were explored from PubMed and equivalent data bases and 300 studies were selected for initial review. Of those 300 studies reviewed, 116 studies were selected for detailed review and inclusion in the annotated bibliography. We focused on studies which used MRI, fMRI, PET imaging, EEG with MEG or QEEG analysis which provided detailed brain mapping relevant to the physical areas which had been clearly designated as involved. The subsequent result of the study is a detailed theory.

6. THEORY IN BRIEF

One of the single most important aspects discovered was community. (CDC, 2005 and Krause, 2002, Gardiner, 2012) There is power in fellowship and strength in sharing when the situation is difficult particularly when music is a part of that sharing. Being greeted as a friend when entering the religious space, being able to sit with friends and family with a feeling of safety allows for the down regulation of the nor epinephrine (fight, flight, freeze) cycle. (Griffith et al., 1984) One experiences a level of relaxation which reduces blood pressure. (Loomba et al. 2012, Ofiki et al., 1999) Further, when individuals sing together they begin to breathe together and their hearts beat together. (Modesti et al, 2013) This creates a feeling of unity in the community and allows for more rapid problem solving. When one was valued in the local community to which one was responsible, it further strengthened both ethical and moral standards of behavior.

Children were often brought to the service. This was important because exposure to music and musical training produces a step-wise modulation in brain response (Oechslin et al., 2012) This change in brain response creates "superior brain architecture" (Tervaniemi et al., 2012) resulting in higher quality executive function, increased ability to focus and an increase in creative abilities and innovative thinking. (E et al., 2012). (Oechslin et al., 2012 and Putkinen et al., 2012) There also begins to be an alignment between the neurological activity and word and meter stress in the music. (Rothermich and Kotz. 2013) Taken in total musical training improves brain plasticity (Herholz and Zatorre, 2012 and Lou et al., 2012) which allows the brain to re-pattern the nervous system, respond more flexibly to varied stimuli and retarget the use of specific nerves.

The impact of the words of the music is both profound and subtle. Physiologically, it allowed neurological repatterning and change in polyvagal response. (Yamasaki et al., 2012 and Paraskevopoulos et al., 2012) This happened because the lyrics themselves redefined and reframed the experience of being a slave. The lyrics gave hope. The use of words defined specific interactions in the world. (Carota et al., 2012) They define the role of the slave owner as the same as the Pharaoh described in the lyrics clearly showing that the slave owner was not in alignment with God's will. (Caldwell, 2004, Gordon et al., 2011) They showed the strength and power in faith in the potential for change (Wilson et al., 2011 and Sammler et al., 2012). As a result the music and lyrics reduce depression and suicide. (Koenig et al., 1992 Ellison, 1995, Young et al., 2003)

The next piece of information of note was involved in the placement of individuals singing in a congregational setting. People singing in a congregational setting often sing slightly different pitches for the same notes. When an individual has different notes sung on either side (microtonal differences) this creates a pseudo-binaural beat situation (Zatorre et al., 2012). Binaural beat music can create cross cortex coherence (Osdamar et al., 2011) altered or spiritually connected states and a reduction in anxiety (Le Scouarnec, 2001) and an increase in the flashes of insight that one experiences. (Backer et al., 2010) Auditory nerves respond nonlinearly to musical stimuli so in addition because more of the brain is engaged in the process, less neurological pruning and greater neuroplasticity is a result. (Large and Almonte, 2012)

The key in which the music is performed also has an impact. Nerve plexus along the mid-line of the body respond to stimuli at different frequency rates. This allows the nerve plexus to both respond to stimuli and supports appropriate release in the nervous system (Sammler et al., 2012

and Manzke et al, 2009). The key of the music can also act as a stimulus to the body system supporting joy responses and deeper self-reflection. (Lehmann et al., 2001) Tempos of the music are also a factor. When individuals are singing in a congregational setting again there can be small variations in tempo between individuals standing side by side. These small variations in tempo create brain changes which support both improved executive decision making (Nozardan et al, 2011 and Jungblut et al., 2012) and recognition of cognitive dissonance. (Kitayama et al., 2012 and Parakevopoulos et al., 2012) The recognition of cognitive dissonance was particularly valuable within the slave community as it allowed individuals to recognize inherently dangerous situations in advance and sometimes be able to mitigate the effects. Further, it underlined the fundamental incorrect nature of the experience in which they were trapped reinforcing the response to the lyrics of the music. Musical activity with very small changes in rhythmic structure is also one of the few know ways in which the volume of grey matter in the brain is increased. (Teki et al., 2012) Overall these two aspects of the musical experience and the involvement in religious activities promote survival. (Previc, 2006) This was particularly important when the potential survival of the individual was limited.

In addition to the other benefits of singing the Negro Spiritual, it improved total breath of the brain, built increased lung capacity over time, (Kleber et al, 2010) increased the blood oxygen ratio (Stevenson et al., 2011) which in turn increases vascular flexibility (Kleber et al, 2010) in the brain. The total effect of participation in the religious activities and the singing of the Negro Spiritual was improved longevity. While it is unknown what the total increase was 200 years ago, today it is over 14 years improvement in longevity. (Hummer et al., 1999, McCullough et al., 2000)

The final effect that we were able to determine was that the period of contemplation included in the service when the body was in balance and properly stimulate created a momentary pause which then resulted in a need for movement. Essentially it is a pause before action. (Chin et al., 2012) Increased longevity, community unity, improved decision making, greater awareness of pending attacks through recognition of cognitive dissonance, better ability to focus, better brain linkages and increased neuroplasticity were all found to be viable and reasonable part of the explanation for both the survival of members of the community and the more limited effects of such deeply life threatening situations.

7. POTENTIAL FOR USE IN SCIENCE

There are a myriad of unanswered questions in history, science and other disciplines. There is an untapped potential in using existing knowledge and combining that with solid, clear, complete problem definitions and reverse engineering key processes. This holds the potential to advance many disciplines more rapidly. Thousands of scientific dollars a year are wasted because problem definition is done so poorly that the hypothesis of an experiment is not asking the correct questions and the experiment does not test even the existing hypothesis adequately. It is critical that as money becomes tighter, research become more precise in the problem definition process.

8. SUMMARY

It may be possible in the future to use this same basic process using the problem definition, reverse engineering analysis and subsequent multi-modal data mining and data analysis to answer existing historical questions with some degree of accuracy. This can advance many fields more rapidly as it clarifies relevant information and places it in historical context.

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Recognizing the Need for Rich Contextualization in the Classroom and Applying it with Modified Bloom's Cognitive Domain Taxonomy for Successful Teaching of Physics 106 (Physics II – Electricity, Magnetism and Light): Phase II—the Complement

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ABSTRACT

Engaging students to teach new concepts is the primary goal of College Education, yet addressing that goal in the sciences and engineering fields remains a formidable task for efficacious teaching and learning. Continuing from Phase I, Phase II rephrases my original two hierarchical teaching-structures as presented and affixes what I call "the Complement," as a vital component, without which both teaching-structures would be rendered more or less feckless. The Complement consists of (1) advancing the use of proper testing, while arguing against using the restricted multiple-choice questions, (2) expressing the need for participating students to attend class with an open-mind, and (3) implementing mutual respect between the instructor and students, or at least acceptance of each other. Also, in this Phase II, the entirety of the two hierarchical teaching-structures using the Complement has been expanded to connect with Intermediate Electricity and Magnetism (PHY 331 and 332) and Physical Science II (PHY 102), and the use of "Subject Learning Convergences" (SLCs), as addressed through RCT, is repeated again for clarity. Finally, I suggest that my hierarchical teaching-patterns yield successful teaching and learning in any academic course where engaging students to teach new knowledge represents the primary focus.

Keywords: Bloom's cognitive taxonomy, Subject Learning Convergences (SLCs), Basic Contextualized Teaching (BCT), BCT-Pattern, Rich Contextualized Teaching (RCT), RCT-Pattern, hierarchical patterns, multiple-choice test questions, student open-mindedness, course navigator, respect or acceptance.

1. INTRODUCTION

When teaching Physics 106 (Physics II - calculus based Electricity, Magnetism, and Light), I routinely use a new cognitive teaching-structure that I have named "Basic Contextualization Teaching (BCT)," which was labeled "contextualization teaching" in Phase I [1]. As a new teaching-structure, BCT is comprised of three independent parts or blocks, which are:

1) Standard teaching methods

- 2) Teacher's attributes
- 3) The last component and the first three components of Bloom's cognitive domain taxonomy

This individual teaching-tool, put forth originally in Phase I, has been designed for gauging initially and continuously, then engaging students to teach new concepts and to achieve content mastery with the successful integration of those concepts with their existing knowledge. In addition, the successful integration of existing knowledge and new concepts as manifested through individualized student learning has been and remains the primary goal of college education. In this regard, I use BCT to help me with the delivery of course materials and to make the abstract nature of Physics II and other related courses that I teach [2-5] less intractable to my students. In Figure (1a), I show a visual rendition of BCT.



Figure (1a) Basic Contextualization Teaching (BCT) diagram

The standard teaching methods, as contained in the left block, are the traditional teaching procedures used in most science and engineering classes: initial assessment of the class is implemented; discussions of content material occur; the instructor issues selected assignments; the completed assignments are provided to the instructor; the assignments are graded and returned to students; tests and other learning projects are given and graded; and finally, letter grades are awarded to the students for course performance. The entirety of a course can begin and end in this manner, although using standard teaching methods alone represents just the first part of my first teaching-structure. Next, in order from left to right is the uppermost block of BCT, the "Instructor's Attributes," with its three subcomponents, are given as:

- 1) Knowledge of the subject material
- 2) Teaching experiences
- 3) Enthusiasm

Needless to say, of the Instructor's Attributes, subcomponent 1, instructor's knowledge of subject material, is absolutely critical for efficacious or effective teaching. The instructor simply must possess the requisite content knowledge, of the course material, that is to be conveyed to the students, otherwise, less than adequate teaching can be expected to occur in the course, and only a diminished return can be gained from the instructor's presence in the class. Also, similarly and at least as critical as the instructor's knowledge of the subject material is, is the instructor's teaching experiences, often without which the instructor is ill equipped to handle the average Physics II class, typically having more than 20+ students. If developed properly, the instructor's knowledge of the subject material and the instructor's teaching experiences lead the instructor to having a greater intellectual-depth and a keenness in the presentation of the course material to the students.

Finally, as the third subcomponent, the Instructor's enthusiasm for the course represents the ending part of the Instructor's Attributes block. Without enthusiasm for the course, the critical motivation mechanism for sharing between the instructor and student is missing. Essentially, in this regard, the course has little or no *rasa* or synergy and thus is robbed of an effective exchange mechanism. These three subcomponents of the Instructor's Attributes remain viable and applicable for me, and I find myself constantly addressing them and working on how to expand my delivery techniques, of content material, for all the physics courses I teach.

The final block of the BCT-structure, as shown on the right side in Figure (1a), equates to uniting into one block the last category and the first three categories of Bloom's cognitive domain taxonomy. Once combined, the four categories with their separate identities—Evaluation, Knowledge, Comprehension, and Application [6-8]—are functional as a group. The essence, of this final BCT-structure, is designed so that the instructor may have an engagement system for teaching the Physics II class. Initially, the engagement is implemented with the Evaluation category and later the other three categories – Knowledge, Comprehension, and Application. Next, all parts of BCT are used in regular teaching sessions.

Table (1) displays the modified Bloom's cognitive domain taxonomy, in its entirety, where BCT, as my first teaching-structure, contains with other critical ingredients only categories 1-4 of the modified taxonomy. The remaining categories, 5-6 of the modified Bloom's

taxonomy (Analysis and Synthesis), are to be addressed and used later.

Table 1: Modified Bloom's cognitive domain taxonomy

1 Evaluation (6)	2 Knowledge (1)	3 Comprehension (2)
Appraise	Locate	Compare
Assess	Define	Match
Support	Write	Summarize
Choose	Recite	Confirm
Compare	Memorize	Transform
Defend Est.	Identify	Restate
Judge	Describe	Explain
Predict	Label	Relate
Rate	Name	Change
Select	Recognize	Predict
Evaluate	State	Extend
4	5	6
Application (3)	Analysis (4)	Synthesis (5)
Make	Select	Hypothesize
Interpret	Analyze	Construct
Solve	Compare	Formulate
Classify	Construct	Organize
Show	Classify	Develop
Model	Separate	Combine
Modify	Categorize	Add to create
Choose	Survey	Produce

As is well documented, Benjamin Bloom in the mid 1950's chaired the committee that created this intellectual classification-scheme or taxonomy, and from that time forward, the taxonomy has been labeled Bloom's cognitive domain taxonomy.

Moreover, in strategizing for teaching effectiveness, I consider Bloom's original categories (1) and (2), which are specified as my categories 2 and 3 in Table (1) [9, 10], to be the low-level intellectual categories and categories (3), (4), and (5) (my categories 4, 5, and 6) to comprise the high-level categories, for Physics II instruction. Evaluation, category (6) of the original Bloom's cognitive domain taxonomy (my category 1), is positioned first and is used as such in my BCT-structure for assessing the ability of the class, initially. Then, category 1 is used periodically during the course for ongoing assessment as needed. The low-level categories 2 and 3 (knowledge and comprehension) and category 4 (application of the high-level) are used more or less during each class session, and, to that extent, BCT as a teaching-structure helps me in routine day-to-day instruction in my Physics II classes. Essentially, these Modified Bloom's cognitive domain taxonomy categories provide in pictorial form a menu of items that support engagement, information exchange and outcome gauging for effective teaching and learning at the first critical thinking level in Physics II.

At this point in Phase II, after re-phrasing BCT, I am obliged to introduce the Complement, which effectuates

the requisite completeness, as defined, for this teachingstructure. The Complement is so simple and seemingly trivial that I omitted it in Phase I, but after only one year of teaching PHY 102, PHY 331, and PHY 332, again, I have come to realize the need to include the Complement as a vital component for all effective teaching-structures. In this regard, the Complement consists of three parts: (1) advancing the use of proper testing, while arguing against using the restricted multiple-choice questions [10], (2) expressing the need for participating students to attend class with an open-mind, and (3) implementing mutual respect, or at least acceptance of each other, between the instructor and students. This mutual respect or acceptance results in allowing basic civility to be present in the learning process. Also, the open-minded student is better positioned to embrace new concepts and unfamiliar materials. Therefore, without the Complement, with its three components, effective teaching and learning cannot occur under any condition, and to that extent, my BCT teaching-structure now is used routinely in partnership with the Complement to form a new unit, the new BCT-Pattern.

On some occasions, during some class sessions, difficult content material to students occurs where a greater effort to achieve teaching effectiveness is required on the part of the instructor. In my Physics II classes, I find that when the BCT-Pattern as described above is insufficient for teaching effectiveness, a Subject Learning Convergence (SLC) is imminent, or has already occurred in the class. At this point, as required, the instructor's teaching approach is critical to the overall success of the class. Failure on the instructor's part to recognize the occurrence of SLCs places the class in the dangerous predicament of not being able to meet the course learning outcomes, in totality. My experiences suggest that better at engaging teachers are able to know, from experience, where SLCs exist in their classes or courses, and they are able to prepare for their impact well before they occur.

Simply stated, for me, as a teacher of Physics II and related courses, I recognize that an SLC is imminent or about to occur when either two or more new concepts must be used together, two or more mathematical equations (formulas) must be manipulated simultaneously, or two or more similar yet variant procedures or operations are required in concert. To teach effectively or to manage my Physics II class properly during SLCs, I have progressed to using a hierarchical teaching-pattern that goes beyond the scope of the newly identified BCT-Pattern, as presented above. As stated in Phase I, the first part of this individual teaching pattern is called "Rich Contextualization Teaching," or "RCT," and as a higher teaching structure than BCT, RCT is depicted in Figure (1b), having a total of five blocks.

In this regard, RCT is an advanced or hierarchical teaching-structure, compared to BCT, and has been

designed for use when the BCT-Pattern proves to be inadequate for effective teaching and learning. The RCT-Pattern, combined of the RCT-Structure plus the Complement, as now used, assists me with content delivery and more than doubles the probability that at least 80% of my Physics II students are able to master the course material successfully, and that the students, concomitantly, are able to pass the class with successful grades at this advanced level of critical thinking. As Figure (1b) shows, the components of RCT, in comparison to BCT, individually display only two additional or new blocks. The first additional block, (right, mid level), is Persistence, which is comprised of the three elements: Rehearse, Recite, and Redo. RCT's Persistence block is virtually self-explanatory. In order for the Physics II students to embrace several newly acquired abstract concepts at once, or integrate a voluminous amount of material, or manipulate two or more equations simultaneously, the students must be engaged with obvious and consistent repetition,



Figure (1b) Rich Contextualized Teaching (RCT) diagram

recitation, and practices, to learn effectively, or they must embrace the adage: "rehearse, recite, and repeat (redo) for excellence."

The final block of the RCT teaching-structure, comprising Analysis and Synthesis, is designed to engage the Physics II student in higher-level intellectual or critical thinking, which on some occasions requires deconvolving or separating existing information on one hand, or the combining of concepts on the other. Both the Analysis and Synthesis categories of the modified Bloom's cognitive domain taxonomy provide additional and critical menu items that add to the menu items already available through the simpler BCT-structure.

Finally, when the BCT-Pattern is insufficient, the RCT-Pattern, comprised of RCT plus the Complement as defined above, allows me to engage students fully for effective teaching and exchanging of knowledge with my Physics II class on the occasions of SLCs. The RCT-Pattern allows me to meet the course learning outcomes in such critical teaching sessions. In this regard, as contemporaneous teaching-patterns, the BCT-Pattern and the RCT-Pattern, to address SLCs, span completely the entire spectrum of what is needed for effective teachingin my Physics II classes. Similarly, these teachingpatterns lend themselves to connect with Intermediate Electricity and Magnetism (PHY 331 and 332), which are more difficult courses than Physic 106, and to Physical Science II (PHY 102) for non-science majors, which is less difficult than Physics 106.

Scores of SLCs occur in Physics II, and even more occur in PHY 331 and 332 but not so many in PHY 102. Below, as in Phase I, I illustrate three such SLCs with related physics problems. The three illustrative convergences, problems, are given as:

- I. Obtain, using Kirchhoff's laws, the unknown currents in a simple multi-loop electrical circuit when other circuit parameters are known.
- II. Obtain the equivalent resistance R_{eq} and the equivalent capacitance C_{eq} when a "resistor bank" and separate "capacitance bank" are given simultaneously.
- III. Obtain the cycloidic motion of a charged particle when moving in a crossed electric and magnetic field if the particle begins at the origin with zero initial speed.

Section 3 of this paper, "Three Illustrations of the Using the RCT-Pattern in Physics 106," considers problems having SLCs and how to address those SLCs effectively using the RCT-Pattern.

2. SCOPE AND RATIONALE FOR BOTH THE BCT-PATTERN AND THE RCT-PATTERN

As indicated previously, I find that a tandem of material and complicated information, pertaining to learning new concepts, does not hinder the students of my Physics 106 classes. Instead, the obstruction to learning results more or less only from the concert or voluminousness of material or when similar yet different material occurs, which make, on these occasions, effective teaching and learning extremely difficult if not impossible.

In this regard, I recognize that the characteristic of students needing both the BCT-Pattern and the RCT-Pattern to address SCLs is not unique to my students at Alabama A&M University (AAMU). On the contrary, I have observed this characteristic in all places where I have previously taught Physics II, ranging from Fayetteville State University, Fayetteville, NC, to the University of Pittsburgh in Pittsburgh, PA, and to Spelman College in Atlanta, GA. My thoughts are that this behavior exists in all academic institutions and plagues some Physics II students of all races and socioeconomic groups, where they study Physics II. Next, the three courses used in this study, to various degrees, are described below:

PHY 106 (Physics II- 4 hrs)

This is the second part of a calculus–based physics course designed for sciences, engineering and technical majors with the same goal as Physics I. Covered topics include: electricity, magnetism, and light. The student will perform at least ten experiments. Prerequisites: PHY 105. Co-requisite: MTH 126.

Other Related Courses:

PHY 102 (Physical Science II)

This course encompasses selected topics in the field of chemistry, geology, meteorology, and astronomy. Covered topics include: period law, crystals, ions, solutions, chemical reactions, atmosphere and hydrosphere, earth materials, the changing crust, earth and sky, solar system, stars, and structure and evolution of the universe. Prerequisites: PHY 101, MTH 101.

PHY 331 (Electricity and Magnetism I)

This is an intermediate level course covering electric force (Coulomb's Law), electric fields (Gauss' Law), electrical potential (Poisson's and Laplace's equation and method - if images), electric fields in dielectrics, capacitors, electrostatic energy, and electric current (Ohm's Law and Kirchhoff Law). Prerequisites: PHY 105, PHY 106.

PHY 332 (Electricity and Magnetism II)

This is the study of magnetic fields (Biot and Savart's Law, Ampere's Law), Faraday's Law of Induction, Inductance, and magnetic energy, A.C. circuit, Maxwell's equations, electromagnetic waves, and electrodynamics. Prerequisites: PHY 331.

3. METHOD: THREE ILLUSTRATIONS USING THE RCT-PATTERN IN PHYSICS 106 WHEN SLCs OCCUR AFTER THE INITIAL USAGE OF THE BCT PATTERN

Illustration I. A Multiloop Electric Circuit Problem

RCT-structure: (a) all the BCT-structure, including APPLICATION - collect, solve, and illustrate; (b) ANALYSIS - analyze and construct; (c) SYNTHESIS - formulate and combine results, Plus the Complement

The required parameters for Figure (2) are shown on the as:

$$V_1 = 6.0V$$
, $V_2 = 12.0V$, $R_2 = 8.0\Omega$, and $R_1 = 4.0 \Omega$

If considering the batteries to be ideal, find the magnitude and direction of the current in each of the three branches. Since there is no method to reduce the circuit to a simpler, equivalent circuit by using Ohm's law, we use firstly Kirchhoff's voltage and current rules to obtain a set consisting of three simultaneous algebraic equations. Then we solve the three equations to obtain the unknown currents, in magnitude and direction.



Figure (2) Multiloop electric circuit

Kirchhoff's current rule applied to node *b* yields:

$$i_3 = i_1 + i_2$$
 (1)

Kirchhoff's voltage rule applied to the left-hand loop yields:

$$-i_1R_1 + V_1 - i_1R_1 - i_3R_2 - V_2 = 0$$
⁽²⁾

Kirchhoff's voltage rule applied to the right-hand loop yields:

$$-i_2R_1 + V_2 - i_2R_1 - i_3R_2 - V_2 = 0 \tag{3}$$

The students are led to solve this set of equations by substituting Eq. (1) into Eq. (2) and Eq. (3) to get the two independent equations, having the same two unknowns, i_1 and i_2 . After substituting the given parameters, the two independent equations become:

$$8i_1 + 4i_2 = -3$$

$$4i_1 + 8i_2 = 0$$
(4)

Resulting values are $i_1 = -0.5A$, $i_2 = 0.25A$, and $i_3 = -0.25A$. The current direction of i_1 and i_3 are reversed as signified by the negative currents.

Illustration II. Resistor and Capacitor Banks Problems

RCT-structure with modified Bloom's components for engaging and gauging: (a) all BCTstructure components; (b) APPLICATION - solve, illustrate and interpret; (c) ANALYSIS - analyze, construct, and compare; (d) SYNTHESIS - formulate and combine, Plus the Complement.

Often students have to determine the equivalent resistance for a "resistor bank" when the circuit contains both series and parallel resistors, and likewise, must determine the equivalent capacitance for a "capacitor bank" when the circuit contains both series and parallel capacitors. In this regard, resistors in series combine in a linear manner, while resistors in parallel combine in a reciprocal manner; capacitors in parallel combine in a series manner. In this problem, the students are given resistors in Figure (3a) and capacitors in Figure (3b). When evaluating each circuit from the battery (V), find the equivalent resistance in Figure (3a) and the equivalent capacitance in Figure (3b) using the formulas and the parameters provided below.

Equivalent resistance and capacitance formulas:

Series Resistors Series Capacitors

$$R_{eq} = R_1 + R_2$$
 $\frac{1}{c_{eq}} = \frac{1}{c_1} + \frac{1}{c_2}$ (5)

Parallel Resistors Parallel Capacitor

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \qquad C_{eq} = C_1 + C_2 \qquad (6)$$

Circuit parameters:

$C_1 = C_6 = 3.00F$	$R_1 = R_6 = 3.00\Omega$
$C_3 = C_5 = 3.00F$	$R_2 = R_5 = 4.00\Omega$
$C_2 = C_6 4 = 2.00F$	$R_2 = R_4 = 2.00\Omega$



Figure (3a) Resistor bank electric circuit



Figure (3b) Capacitor bank electric circuit

Using the required formulas for combining resistance in Figure (3a) and the capacitors in Figure (3b), the results obtained are:

$$C_{eq} = 3F$$
 $R_{eq} = 1.56\Omega$

Illustration III. Cycloidic Motion and its Specific Conditions, for a Charged Particle Moving in Crossed Electric and Magnetic Fields - a Connection to Intermediate E&M

RCT-structure with modified Bloom's components for engaging and gauging: (a) the BCTstructure, with APPLICATION - solve, illustrate, and interpret; then (c) ANALYSIS - analyze, construct, and compare; (d) SYNTHESIS - formulate and combine equations Plus the Complement

Cycloidic Motion: Consider that the magnetic induction \vec{B} points in the x-direction, and the electric field \vec{E} is in the z-direction, as shown in Figure (4). A proton is released from the origin. What path will the proton follow?

Analysis: Initially, the electric field dominates the motion, accelerating the proton upwardly along the positive z-axis and increasing the speed as well, thus allowing the magnetic force to change from zero at the origin to dominate the motion by eventually curving the proton circularly until the proton is now moving in the negative z-direction, where the proton is finally stopped by the opposing electric field. This pattern ensures and repeats again, and again, continuously moving the proton in an exotic manner, tracing out the cycloidic motion while moving cycloidically along the positive y-axis.

This motion, though peculiar, is governed by the Lorentz force law, $\vec{F} = Q(\vec{E} + v \times \vec{B})$, where Q is the particle's charge, the position vector of the motion is $\vec{r} =$ (0, y(t), z(t)), and the corresponding velocity vector is $\vec{v} = (0, \dot{y}(t), \dot{z}(t))$, where the dots denote time derivatives. Now, Lorentz's force law,

$$\vec{v} \times \vec{B} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0 & \dot{y} & \dot{z} \\ B & 0 & 0 \end{vmatrix} = B\dot{z}\hat{y} - B\dot{y}\hat{z}$$
 (7)

after substituting, becomes

$$\vec{F} = Q(E\hat{z} + B\dot{z}\hat{y} - B\dot{y}\hat{z}) = ma = m(\ddot{y}\hat{y} + \ddot{z}\hat{z})$$
(8)

After separating variables, using vector analysis and Newton's second law of motion, where *m* is the particle's mass, two coupled differential equations are obtained as:

$$QB\dot{z} = m\ddot{y} \text{ and } QE - QB\dot{y} = m\ddot{z} \tag{9}$$

For convenience, on letting $\omega = QB/m$ and inverting the equation, Eq. (9) becomes

$$\ddot{y} = \omega \dot{z}, and \ \ddot{z} = \omega (E/B - \dot{y})$$
 (10)

Now, on taking the first derivative of Eq. (10) and substituting the results into Eq. (9), two decoupled third-order differential equations are obtained as:

$$\ddot{y} + \omega^2 \dot{y} = \omega^2 E/B$$
 and $\ddot{z} + \omega^2 \dot{z} = 0$ (11)

The solutions to these equations are [4]:

$$y(t) = C_1 \cos \omega t + C_2 \sin \omega t + (E/B)t + C_3$$

$$z(t) = -C_1 \sin \omega t + C_2 \cos \omega t + C_4$$
(12)

With the specific initial conditions, of the proton being initially located at the origin with a zero velocity, the four constants of integration above become

$$C_1 = 0, C_2 = -E/\omega B, C_3 = 0, and C_4 = E/\omega B$$
 (13)

yielding the solution:

$$y(t) = \frac{E}{\omega B} (\omega t - \sin \omega t) \text{ and}$$
$$z(t) = \frac{E}{\omega B} (1 - \cos \omega t)$$
(14)

On eliminating the sine and cosine terms, using the expression $\sin^2 \omega t + \cos^2 \omega t = 1$, the two independent equations combine to yield

$$(y - R\omega t)^2 + (z - R)^2 = R^2$$
(15)

which is the equation of a circle of radius R, whose center located at $(0, R\omega t, R)$ moves along the y-axis at a constant speed u=E/B, depicting the cycloidic motion.

Interpretation: What are the maximum and minimum heights along the z-axis, and when does the particle return to be on the y-axis? Answers: The maximum height occurs when $\dot{z} = 0$ and $\ddot{z} < 0$ yielding $z_{max} = 2R$ and the minimum height occurs when $\dot{z} = 0$ and $\ddot{z} > 0$ yielding $z_{min} = 0R$, and y = 0 at times $t = 2\pi n/\omega = 2\pi mn/QB$, where n=1, 2, 3...



Figure (4) Cycloidic Motion of a proton along the y-axis

4. DISCUSSION

In previous sections, the new definitions of BCT and the continued definition of RCT were presented, with their individual descriptions. Regarding my first teaching and learning structured, BCT, Phase II has affixed to BCT what I call the Complement, for which without its ongoing use, the learning process is rendered more or less feckless. Moreover, the Complement consists of (1) advancing the use of proper testing, while arguing against using the restricted multiple-choice questions in classes, such as in Physics 106, (2) expressing the need for participating students to attend class with an open-mind, and (3) implementing mutual respect between the instructor and students, or at least acceptance of each other. Implementing respect or acceptance allows basic civility to exist in the learning process, and when BCT is used with the Complement, resulting in the BCT-Pattern, for first-level critical thinking, my teaching-structure is complete and functional for its intended purpose. The BCT-Pattern enables the instructor in Physics II to teach effectively or efficaciously through routine class sessions and is particularly applicable when students are learning less abstract concepts or at least, abstract concepts that are presented in a tandem or sequential manner. This teaching-pattern allows one idea to be digested and acted upon before the occurrence of many other new ideas or the onset of additional information. In Physics II, under the BCT-Pattern, the student can digest singularly new material, comprehend the material and apply the material in an effective manner before progressing to the next question.

In this phase II, the Complement as presented above has three vital components. Firstly, proper testing as the first component is required in each course, and thus argues against using the restricted multiple-choice test question. The restricted multiple-choice question, in Assessment, entered academia nearly 100 hundred years ago during the time period of World War I (1914-1918), and its popularity has increased so widely since that time that this test format is currently the dominant mode of assessment in low-level college courses throughout the United States of America. And since test questions often serve as the "navigator" of a course, the multiple-choice test questions, unfortunately, steer the class toward lowlevel learning or stifled learning at best. Next, effective or efficacious learning is near-to-impossible if the student does not have an open-mind towards the material being presented, and if civility does not exist in the learning process.

Moreover, even with the Complement in full operation, as defined above, and using BCT plus the Complement, resulting in the BCT-Pattern, there arises a need to provide the Physics II instructor with a more efficacious technique to engage students during some class sessions. In my estimation, this need arises most often when a subject learning convergence (SLC) is imminent in the course or one has already occurred. At the onset of an SLC, higher cognitive levels of critical thinking or intellectual processing must be used in Physics II and related courses. The SCL typically occurs when course material occurs in a voluminous amount, or simultaneous manipulations are required in formulas or equations, or numerous newly learned concepts occur in concert. In this regard, while effective for first level critical thinking, I recognize that my BCT-Pattern is often ineffective to address SLCs when they occur in Physics 106 and related courses.

To address the onset of SLCs, I have progressed to a new unit, the RCT-Pattern, which includes the RCT-structure, as defined, Plus the Complement. The RCT-Pattern can be used for effective teaching at this junction. Not knowing beforehand or not being able to adjust to an SLC quickly after it occurs places the class in jeopardy of not meeting the course learning outcomes; but once recognized, the RCT-Pattern is totally effective for efficacious teaching and learning on this higher level of critical thinking. Finally, in this regards, I have repeatedly suggested that RCT-structure plus the Complement, to address SCLs, resulting in the higher RCT-Pattern, can be used not only in Physics II, but in all other academic courses where engagement to teach new concepts is the primary concern.

5. RESULTS

The followings are several obvious results of this study, spanning both Phase I and Phase II:

- 1) A comprehensive re-description of BCT with its three parts has been given. The definition has three parts (blocks), which are:
 - a) Standard teaching methods
 - b) Instructor's attributes
 - c) The last category and first three categories of Bloom's cognitive domain taxonomy
- 2) The meaning of a subject learning convergence (SLC) has been given in full detail.
- The definition of RCT with its five parts (blocks) has been given, which are the previous three parts of BCT given above (a - c), and the addition of the new parts below (d - e)

d) The two other components of Bloom's Taxonomy - Analysis and Synthesis
e) Persistence

- 4) The definition of the Complement has been given.
- 5) Both BCT plus the Complement, resulting in the BCT-Pattern, and RCT plus the Complement, to address SLCs, resulting in the RCT-Pattern, and coexisting in a hierarchical manner, as effective teaching-patterns, have been given.
- 6) Three illustrations, using the RCT-Pattern to address SLCs, have been demonstrated using course material

from PHY 106 and PHY 331 with a connection to PHY 332 and PHY 102.

- 7) Enthusiasm is an effective attribute to allow the exchange of information between the instructor and students.
- Arguments are emerging against the debilitating effects of the restricted multiple-choice questions in testing, which, unfortunately, navigate classes into stymied learning.
- 9) Open-mindedness and civility must exist in all classes for effective teaching and learning to occur regardless of whichever teaching pattern is been used.
- 10) I am quite convinced that the BCT-Pattern exists as an effective, efficacious teaching-pattern and can be used routinely in all academic courses where engagement to teach is the primary concern and the RCT-Pattern can be used in such courses when SLCs arise.

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Mutual Influence of Management Processes of Stakeholders and Risk Management in Cyber Security Environment

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ABSTRACT

The objective of the stakeholders' management is to find out promoters who can significantly help us at problem solving in cyber security environment (including those who must be integrated into the risk management). On one side there is a necessity to find opponents who can become partakers of generated threat and who make an effort to prevent the set objectives to be achieved/or to inflict a significant damage by way of found vulnerabilities of critical assets (risk scenario). Knowledge of the stake holders according to their interests, objectives, influence on the objective set, and their knowledge in the field of cyber management belong to the key knowledge to be able define the attitude strategies towards stake holders in cyber security environment. During further monitoring the implementation of attitude strategy it is possible to assess the success of realized activities towards stake holders.

Risk management of cyber security comes out from identification and analyses of human resources assets (stakeholders), that must be protected against the threat impacts of cyber security. It also comes out from identification of promoters who generate the threats of cyber security (stake holders – opponents). After a risk judgment the stake holders who are crucial from the point of controlling the risk (implementation of proposed activities to control and monitor risks) are identified.

Keywords: Asset, Human resources, Risk management, Stakeholder management, Supporter, Opponent, Process, Threat.

1. INTRODUCTION

Information and communication technologies are currently a part of all organizations. Management without these technologies is virtually impossible. People (citizens, managers, politicians) have become dependent on information and communication infrastructure when managing the society, business and their private lives. We, as stakeholders, use these technologies to enter the cyber environment. This means, however, that we also encounter the risks of the cyber environment.

As well as we manage everyday risks connected to our daily routines (e.g. driving a car or riding a bike) we have to purposely manage the risks connected to information and communication technologies (both from the supplier's and customer's points of view). However, the problem of today is to manage the right risks in an adequate way making use of active participation of stakeholders that have corresponding abilities to participate in risk management.

Companies should see risk management as a process that helps create values for stakeholders using their own resources to optimize costs towards the realizing value (creating added value). On the other hand, organizations also have to know those stakeholders that try to impede meeting the targets via generated threats. That is why the stakeholder management should be seen as a process that helps with the risk management; thus create required value for stakeholders.

2. RISK MANAGEMENT AND STAKEHOLDER MANAGEMENT PROCESSES

The process of risk management consists of 5 sub-processes – establishing the context, risk assessment, risk management, monitoring and review, communication and consultation (see Figure 1). Establishing the context as the first sub-process plays an important role during the process of setting up the risk management criteria based on understanding the specified goal, defined activities and resources needed to achieve this goal. Required outputs coming out of the process of establishing the context include the list of participants (stakeholders – opponents) and threats, the list of evaluated assets (including human resources – stakeholders), critical factors and vulnerability. The output from the risk assessment and risk

management analysis is a risk register or a risk managing plan. These documents contain the risk owners and human resources needed to manage the risks (stakeholders). Monitoring and review sub-processes (parallel sub-process) is feedback, output of which are updated documents coming out of the subprocesses of establishing the context, risk assessment and risk management. Communication and consultation sub-processes (parallel sub-process) serve as information transfer between individual sub-processes. Both sub-processes are realized by stakeholders. [1, 2]



Figure 1 Risk management process (authors according to ISO 31000)

The goal of the risk management is to increase the probability that set up goals will be achieved at all management levels, create real bases for the decision making process, and efficiently use the resources (also human resources) of the organization to manage the risks with as minimum losses as possible.

The risk management process description points out the relation of stakeholders that directly participate in this process or are influenced by this process (in both positive and negative ways) and that can influence this process in both positive and negative ways. [5]

The stakeholder management process includes the following steps: establishing the context, success criteria and requirements identification, stakeholder identification and levels of interest, analyses and evaluation, strategy creation, monitoring of changes (internal, external) and satisfaction of stakeholders. Monitoring is a feedback step for incorporating identified changes into individual steps (see Figure 2). Outputs of individual steps are formulated in Figure 2.



– – – – – → feedback

Figure 2 Stakeholder Management Process (own source)

Stakeholders identification and levels of their interest includes searching people, interest groups, and organizations; their sorting and classification. Goals and interests that are followed by stakeholders are described within the stakeholder identification.

Stakeholder analysis lies in identification of their knowledge of the goal and ways to achieve it. Information concerning interest, power and direction (supporter, opponent), stakeholders' influence, relations among them (coalitions, opponents) is analyzed. The stakeholder who has a high level of interest and influence is assessed as a key one; then it is stated whether it is a supporter or an opponent.

When analyzing, attention must be paid to those stakeholders who do not have big influence but only big interest. Created coalitions of stakeholders with a high level of interest and low level of influence can cause a situation when the coalition members become the key ones because their collective influence can be big. Figure 3 demonstrates the influence of creating coalitions between parts B, C (supporters) and E, F (opponents). Creating a coalition of stakeholders with low influence and high interest makes these stakeholders the ones with high influence and interest. Such stakeholders must be taken into account. The stakeholder analysis is rounded off by their final judgment.



For all stakeholders, strategy creation is the last but one process step in the stakeholder management process. An analysis of stakeholders is a starting point for strategy creation against the stakeholders. In a team there is usually a person responsible for realization of the given strategy, monitoring of changes and satisfaction of key stakeholders. Approach strategy towards stakeholders can be divided into 5 basic groups: inform, consult, include, cooperate and authorize. Approach strategy as well as its content is chosen on the basis of interest, level of influence, knowledge and abilities of the particular stakeholder.

The goal of stakeholder management in the process of risk management is to find and efficiently use own human resources, find those human resources that need to be protected from threats. It is also necessary to find those stakeholders who have the ability and intention to generate threats and who dispose of corresponding power to use the threats (misuse existing vulnerability). [3]

3. COMMON POINT WITHIN THE PROCESSES OF STAKEHOLDER AND RISK MANAGEMENTS

In the process of risk management and stakeholder management following common decision points have been identified:

- a) Critical assets selected (establishing the context) / identified and analyzed the necessary stakeholders to implement activities to achieve the objectives (including the owners of these assets),
- b) Threats identified (establishing the context) / identified and analyzed actors (stakeholders) who have the ability and intention to generate threats,
- c) Defined measures / goals are acceptable considering the new assessment of risk level – shown in the risk profile (risk managing) / identify and analyze stakeholders needed to manage the risks by aggregating,
- d) Unmanageable risk transfer (escalate) to the senior manager (risk management) / identify and analyze stakeholders needed to manage the risk by escalation,
- e) Risk managing changed senior manager's decision (based on aggregation of identical and dependent risks into a unified risk profile) / identify and analyze stakeholders needed to manage the risks by aggregating,
- f) Risk owners identified and authority delegated to the preparation or implementation of measures to manage risks (risk managing) / identify and analyze stakeholders needed to manage risk (risk owners).

The common decision points described above indicate the need to implement the process of stakeholder management in two cycles. After the risk escalation process there is another cycle of the stakeholder management process at the level of a senior manager. During the dependent risk aggregation the stakeholder management process cycle is carried out twice because even the process of risk management is carried out from the beginning (context). [4]

Based on the analysis of both processes it is possible to create a unified model of risk management and stakeholder management processes (see Figure 4). The unified model works on the analysis of common features of risk management and stakeholder management processes. The model of the processes (see Figure 4) is designed to achieve the desired goal in both risk management as well as in stakeholder management.


Figure 4 Unified process of risk management and stakeholder management (own source)

4. CONCLUSIONS

Cyber security is not only technical means and information. Cyber security is controlled by people (stakeholders) who cooperate or try to make use of the vulnerability of assets to their own benefit (to achieve their own goals). These are the people who control the technical means and create information that is shared by them. Cyber security risk management thus cannot be realized independently on stakeholder management because people actively participate in this process and are influenced by it.

The process of stakeholder management must be cyclically repeated. It is necessary to realize the first cycle of the stakeholder management process in a sub-process of establishing the context of risk management in order to recognize own assets (human resources within an organization) as well as assets outside an organization (customers, subcontractors). The point is to recognize the stakeholders that we need to achieve our goal (activities realization) and protect them. These stakeholders can significantly help with risk identification, analysis and generation of risk management variants. As for the first cycle we have to focus on stakeholders' identification – actors (identification of actors). Actors can generate threats (ability and intention) and affect the vulnerability of assets (make use of an opportunity).

The second cycle of the stakeholder management can be seen in the sub-process of risk management. The purpose of this cycle is to find suitable human resources necessary to risk managing considering the choice of suitable strategy necessary to manage the risks.

In the field of cyber security, recognition of assets (their vulnerability) and actors (their ability to generate threats) is one of the key points necessary to define measures that prevent /reduce losses within an organization and their customers.

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Myotube Cultured on Micro Coil Spring

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ABSTRACT

Myoblasts have been cultured on a micro coil spring to estimate forces generated among the tissue of cultured myotubes. A micro coil spring made of titanium wire of 0.085 mm was used for the scaffold for the cell culture. The coil has the dimension as follows: 0.65 mm diameter, 0.05 mm pitch, 5 mm length. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was seeded at the concentration of 10000 cells per cm². The cells around the coil were observed with an inverted phase contrast microscope. The experiment shows the following results. Cells are able to adhere around the coil, proliferate, differentiate into myotube, make cylindrical layer around the coil, and bridge between the pitches of coils. The force, which is generated in myotubes pulling the wires between pitches, is estimated to 0.01 N.

Keywords: Biomedical Engineering, C2C12, Micro Coil and Differentiation.

1. INTRODUCTION

Cell culture technique has been developed and several methodologies have been clinically applied to regenerative medicine [1]. The acceleration technique for orientation and proliferation of cells has been studied to make a biological tissue *in vivo* or *in vitro* [2-4]. Control methodology for behavior of cells would be applied to regenerative tissue technology: orientation, proliferation and differentiation.

The effect of the surface of the scaffold on cell culture has been studied in the previous studies [5, 6]. Several factors, which control adhesion of biological cells, have been studied *in vitro* [7].

When cells make a tissue, they might be pulling each other to keep the morphology. The force generated in the tissue might be estimated with the restoring force of the scaffold.

In the cell culture, myoblasts differentiate to myotubes, which have potential to generate repetitive contraction with stimulation of electric pulses. When the scaffold has resistance to contraction, the myotubes make movement of repetitive contraction with the scaffold.

In the present study, myoblasts have been cultured on a micro coil spring to estimate forces generated among the tissue of cultured myotubes.

2. METHODS

Micro Coil

A micro coil spring (Hi-Lex Corp., Takarazuka, Japan) made of titanium wire of 0.085 mm diameter was used for the scaffold for the cell culture (Fig. 1). The coil has the dimension as follows: 0.65 mm diameter, 0.15 mm pitch, 5 mm length.

Cell Culture

The micro coil spring was placed in the micro-plate of 24 wells of flat bottom of polystyrene (Fig. 2). The internal diameter of each well is 15 mm.

The sixteenth passage of C2C12 (Mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was seeded at the concentration of 10000 cells per cm².

C2C12 was cultured with the D-MEM (Dulbecco's Modified Eagle Medium) in the incubator for 37 days at 310 K with 5% of carbon dioxide gas. The medium contains FBS (fetal bovine serum) with volume percent of 10. The medium also contains penicillin streptomycin with volume percent of one.

The whole body of the micro coil was dipped in the culture medium during cell culture.



Fig. 1: Micro coil spring.



Fig. 2: Micro-plate of 24 wells.

After four days of culture, the coil was moved to another micro-plate to be separated from the cells on the bottom of the micro-plate. The cells on the coil were successively cultured for another four weeks. The medium was changed every two days. The content of the medium was changed to D-MEM (Dulbecco's Modified Eagle Medium) containing 5% HS (horse serum) and 1% penicillin streptomycin on the thirteenth day of culture.

The cells around the coil spring were observed with an inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo) every day.

Spring Constant

The spring constant of the coil (k [N/m]) is calculated by Eq. 1.

$$k = F / x = G d^{4} / (8 N D^{3})$$
(1)

In Eq. 1, F is force [N], x is displacement [m], G is modulus of transverse elasticity of the wire [Pa], d is diameter of wire [m] N is number of turns, and D is diameter of the coil [m].

$$E = 2 G (1+n) \tag{2}$$

In Eq. 2, E is Young's modulus, and n is Poisson's ratio. In titanium, $E = 10^{11}$ Pa and n = 0.3 make $G = 4 \times 10^{10}$ Pa.

In the micro coil spring of titanium used in the present study, $G = 4 \times 10^{10}$ Pa, d = 0.085 mm, N = 30 turns, and D = 0.65 mm make k = 40 N/m.

When the dimension of a pitch of the coil varies 0.01 mm, the local force at one turn is 0.01 N.

3. RESULTS

Fig. 3 exemplifies C2C12 cultured for two days. In the figure, most of cells are on the bottom of the dish. After the coil was moved to another micro plate, many cells are attached on the coil.

Cells start to adhere to the coil in four days, and proliferate to cover the surface of the coil in five days of culture (Fig. 4). In two weeks of culture, some of cells exfoliate, when the coil is

slightly vibrated during handling of culture. Most of cells, however, keep adhesion to the coil in three weeks of culture. Several myotubes are observed around the coil in two weeks of culture (Fig. 5). Most of myotubes tend to be oriented in the parallel direction to the wire of the coil.



Fig. 3: C2C12 cultured 2 days around micro coil. Dimension from left to right is 2 mm.



Fig. 4: C2C12 cultured 5 days on micro coil. Dimension from left to right is 2 mm.



Fig. 5: C2C12 cultured 9 days on micro coil. Dimension from left to right is 2 mm.



Fig. 6: C2C12 cultured 17 days on micro coil. Dimension from left to right is 2 mm.



Fig. 7: C2C12 cultured 29 days on micro coil. Dimension from left to right is 2 mm.



Fig. 8: Myotube on micro coil. Dimension from left to right is 1 mm.

Some of the pitches of the coil decrease at the level of 0.01 mm, when several myotubes are formed around the coil (Figs. 6 & 7).



Fig. 9: Hybrid actuator of micro coil spring with myotube: axial (A) and spiral (B) direction.

4. DISCUSSION

After separation from the cells on the bottom of the micro-plate, most of cells are kept on the coil in the present experiment. The cells proliferate, and differentiate keeping contact with the coil.

When cells make tissue, a space for supplying medium is necessary around cells. A coil has a spiral space along the wire. The space might give a path for the medium approach to the cells.

In the previous studies, the several kinds of acceleration technique to make orientation of cells were tried *in vitro*: with the shear flow [2], with the gravitational force [3], with the nanofiber [8], or with the morphology of the surface [5, 6]. The micro coil spring gives a good scaffold for cell culture. The spiral morphology of the coil might make the spiral orientation of myotubes (circle in Fig. 8).

C2C12 is able to adhere and proliferate on the surface of the micro coil spring of titanium. The cells are also able to differentiate into myotubes around the coil spring.

The coil spring deforms in proportion to the force. The force generated in the muscle tissue cultured on the coil might be estimated by the displacement of the coil. The force generated in the tissue in the present experiment is estimated to 0.01 N by the displacement of 0.01 mm of the pitch of the coil. The force might be generated between the myotubes or in the myotube. The estimated force by the deformation of the coil is axial direction of the coil. The direction of the force generated in myotube might be longitudinal direction of the myotube, which is oriented to the spiral direction of the coil (Fig. 8).

The movement of cultured myotubes is able to be controlled with electric pulses supplied to the medium [9]. If the coil generates resistant force against the contractive force generated by myotubes, the coil covered with myotubes has a potential to make a repetitive contractile actuator [10-12]. The laser system has been applied to measure the cyclic movement in the biological system [13].

Titanium is one of the materials, which has been used for biological application [14]. Titanium has been implanted to human body as a strut of valves, a root of teeth, pins in orthopedic treatment, and a part of joint.

The morphology of micro channel has simulated the lymph system in the circulatory system *in vivo*. In several studies, permeability has been tried to control in designing artificial vessels. The micro spring has a potential to be applied to the scaffold for the micro channel.

The experimental results will contribute to estimate forces generated in the tissue of myotubes.

5. CONCLUSION

Myoblasts (C2C12) have been cultured on a micro coil spring to measure forces generated among the tissue of cultured myotubes. A micro coil spring (0.65 mm diameter, 0.05 mm pitch, 5 mm length) made of titanium wire of 0.085 mm was used for the scaffold for the cell culture. The experiment shows that cells are able to adhere around the coil, proliferate, differentiate into myotube, make cylindrical layer around the coil, and bridge between the pitches of coils. The force, which is generated in myotubes pulling the wires between pitches, can be estimated with the spring constant.

6. ACKNOWLEDGMENT

Authors thank to Hi-Lex Corp. for supply of the micro coil spring. This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Detect of Sublethal Damage with Cyclic Deformation of Erythrocyte in Shear Flow

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ABSTRACT

The deformation of an erythrocyte has been observed microscopically in the shear flow to detect the sublethal damage of an erythrocyte in vitro. A rheoscope system has been manufactured to observe the deformation of the suspended erythrocytes in the shear flow. The rheoscope consists of a pair of parallel disks and an inverted phase-contrast microscope. The human erythrocytes were suspended in the dextran aqueous solution, which has high viscosity. The erythrocytes are sheared in the Couette flow between a pair of counter rotating disks. The experiments with the rheoscope show following results. The erythrocytes deform from a biconcave to an ellipsoidal shape. The erythrocytes deform periodically at the double frequency of tank tread motion of the membrane of the deformed erythrocyte, when erythrocytes have the sublethal damage on the membrane.

Keywords: Biomedical Engineering, Erythrocyte, Shear Flow and Sublethal Damage.

1. INTRODUCTION

An erythrocyte has flexibility [1, 2] and deforms in the shear flow [3]. It also passes through micro-circulation, of which the dimension is smaller than the diameter of the erythrocyte. After circulation through the blood vessels for days, the erythrocyte is damaged and trapped in the micro-circulation systems.

The deformation of erythrocytes has been observed *in vivo* and *in vivo* with various methods: a micro-channel [1, 2, 4], a filter [5, 6], a micro slit [7, 8], and a rheoscope [3, 9]. While erythrocytes are exposed to the shear flow, they show tank tread motion at the membrane [10], and eject contents (hemolysis [11]) through the crevasse of the membrane, before fragmentation.

In the present study, the deformation of erythrocyte has been observed microscopically in the shear flow to detect the sublethal damage of erythrocyte *in vitro*.

2. METHODS

Rheoscope System

A rheoscope system has been manufactured to observe the

deformation of the suspended erythrocytes in the shear flow (Fig. 1). The rheoscope consists of a pair of parallel disks and an inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo) [3, 9]. The erythrocytes are sheared in the Couette flow between a pair of counter rotating disks made of transparent polymethacrylate. The velocity of the middle plane between the counter rotating disks is zero in the shear field of Couette type flow, so that the erythrocyte in the plane is easily observed with the microscope.

The radius and thickness of the disk is 30 mm and 2 mm, respectively. The distance between the rotational axis and the observation point is 20 mm. The lower disk has a wall at the rim. With a DC motor, the rotational speed of each disk is controlled between 0.05 rad s⁻¹ and 0.3 rad s⁻¹. The distance between two disks is adjusted between 0.02 mm and 0.1 mm. The distance is confirmed by the volume of the suspension filled between the disks (between 0.06 cm³ and 0.3 cm³), and by the calibrated focus positions with the microscope.

The shear rate $G[s^{-1}]$ is calculated by the following equation.

$$G = v / D \tag{1}$$

In Eq. 1, *D* is distance [m] between two parallel disks, and *v* is the circumferential velocity difference between of the disks [m s^{-1}].



Fig. 1: Rheoscope system.

The circumferential velocity difference is calculated by Eq. 2.

$$v = r w \tag{2}$$

In Eq. 2, r is the radius [m], and w is the angular velocity difference [rad s⁻¹] between the disks.

At the observation point (r = 0.02 m), the shear rate (G) is in the range between 20 s⁻¹ and 600 s⁻¹, calculated with w (between 0.1 rad s⁻¹ and 0.6 rad s⁻¹) and with D (between 0.02 mm and 0.1 mm) in the present experiment.

Erythrocyte Suspension

Erythrocytes were sparsely suspended in the dextran (molecular weight: 200000-300000) aqueous solution, which has high viscosity.

The shear stress (S [Pa]) in the suspension is calculated by Eq. 3.

$$S = N G \tag{3}$$

In Eq. 3, *N* is the viscosity [Pa s] of the fluid, and *G* is the shear rate $[s^{-1}]$ between the disks.

Variation was made on the shear stress (between 5 Pa and 30 Pa) with *N* (between 0.1 Pa s and 2.6 Pa s) and with *G* (between 20 s⁻¹ and 600 s⁻¹) in the present experiment. The viscosity of the dextran aqueous solution was measured with a cone and plate type of viscometer.

The human erythrocytes from volunteer are used in the present experiment. Before measurement of deformation, the cells were classified according to the density by a centrifugal method [2]. The density of content in cells increases with aging *in vivo*. The fluid of phthalate-ester with controlled density was used as a separator. The younger cells were collected from 10 percent of the supernatant section after centrifugation.

The erythrocytes were suspended in a dextran aqueous solution to separate each other and to load the high shear stress at the low shear rate. The cells were sheared in the Couette flow between two counter-rotating parallel disks at 298 K.

The deformation of cells was observed with the microscope and recorded with a video camera system. The long-focus objective lens is used to observe erythrocytes suspended near the middle plane.

3. RESULTS

Fig. 2 exemplifies deformation of erythrocytes from a biconcave to an ellipsoid, which are observed with the rheoscope system manufactured in the present study. The media moves from left to right in the front layer, while the media moves from right to left in the rear layer. The erythrocytes in the middle layer are able to be observed for a long time within the focused area with the microscope, while the erythrocytes are sheared in the Couette flow (Figs. 2-5). Most of erythrocytes keep the biconcave shape moving along the flow of the slow velocity in the low shear stress field. Some of the erythrocytes roll over and deform to the parachute shape (Fig. 2(A)). Every erythrocyte, on the other hand, deforms to ellipsoid in the high shear stress field (Fig. 2(B)).

The ellipsoid is elongated, as the shear stress increases. The direction of the major axis of the ellipsoid is oriented in parallel to the flow.

After exposure to the high shear stress field for several minutes, some of erythrocytes are destroyed into fragments. Some fragmented flasks adhere to the membrane of the erythrocyte. Fig. 3 exemplifies the tank tread motion of the membrane of erythrocyte at the shear rate of 20 s⁻¹ with the viscosity of 0.45 Pa s. The adhered flask on the membrane is observed as a marker for the movement of the membrane. The marker of the membrane moves left to right on the front side, turns around to the rear side and moves from right to left on the rear side.

The tank tread motion of every ellipsoid with the same cycle confirms the uniform shear field of the Couette flow between the counter rotating disks, which are located at the front and the rear position of the observation window with the microscope. The rotational axis of the tank tread motion is perpendicular to the flow, and is parallel to the disk. The axis is from top to bottom in Figs. 3-4. The frequency of tank tread motion (>1 Hz) is proportional to the shear rate (>20 s⁻¹) between the disks.

After exposure to the high shear stress field for several minutes, some of erythrocytes repeat the cyclic deformation. Fig. 4 exemplifies periodical deformation of an erythrocyte of the ellipsoidal shape in the shear field of Couette flow at the shear rate of 25 s⁻¹ with the viscosity of 0.45 Pa s. The ellipsoid deforms from swollen to flat, while the membrane rotates with the quarter cycle of tank tread motion. The ellipsoid returns from flat to swollen, while the membrane rotates with the successive quarter cycle.



Fig. 2: Deformation of erythrocytes from biconcave (A) to ellipsoid (B). Dimension from left to right is 1.5 mm.



Fig. 3: Tank treading motion of the membrane of erythrocyte. Adhered fragment on the membrane (arrow) is moving from left (A) to right (D). Dimension from left to right is 0.03 mm.





Fig. 4: Repetitive cyclic deformation of erythrocyte, which has sublethal damage. The ellipsoid deforms from swollen (A) to flat (E), and return to swollen (H). Dimension from left to right is 0.03 mm. Two cycles of deformation for one cycle of tank tread motion.



Fig. 5: Damaged erythrocyte. Separated to small spheres (A). Ejected contents (arrow) through the crevasse of the membrane (B). Dimension from left to right is 0.03 mm.

The deformation repeats two cycles at each tank tread cycle. The cycle of the tank tread motion is the same as another erythrocyte, which does not demonstrate cyclic deformation.

Fig. 5 exemplifies damaged erythrocytes, after exposure to the high shear stress field for several minutes. Some cells eject the contents through the crevasse of the membrane. When the direction of the ejection is parallel to the rotating axis of tank tread motion, repetitive cyclic deformation is not observed. In that case, the tank tread motion is observed. A cell is divided into two parts in Fig. 5(A).

4. DISCUSSION

In Fig. 2, every cell in two-dimensional projection shows ellipse, which means ellipsoidal shape. The disk should show circle or ellipse in two-dimensional projection according to the direction.

The shear rate between two parallel disks increases in proportion to the distance from the rotational axis. The shear rate varies with less than 5 percent in the observation area of 1 mm square, of which distance from the rotational axis is 20 mm. The shear rate in the observation area is approximately mean value in the whole volume of the suspension between two disks.

Direction of a rotational movement of the marker follows the shear field. In the shear field, the difference between speeds of two layers ($V \text{ [m s}^{-1}\text{]}$) is calculated by Eq. 4.

$$V = G x \tag{4}$$

In Eq. 4, *G* is shear rate $[s^{-1}]$, and *x* is the distance of the two layers [m]. *V* is 0.02 mm s⁻¹ at *G* of 20 s⁻¹ with *x* of 0.001 mm. The speed of tank tread motion of the membrane depends on the difference of the speed of circumferential flow. The speeds observed in the present experiment are in the same order of *V* calculated by Eq. 4, so that the frequency of the cyclic tank tread motion is higher than 1 Hz.

The repetitive cyclic deformation reveals the local defect of the membrane of the erythrocyte, because the cycle is synchronized with the tank tread motion of the membrane (Fig. 4). During the tank tread motion, the membrane is subjected to tension and compression alternately according to the curvature (Fig. 6). During the tank tread motion of the membrane, the damaged point is moving along the circumference of the ellipsoid, which has cyclic variation of curvature. The cyclic variation of curvature makes cyclic deformation of the ellipsoid.



Fig. 6: Two cycles of tension and compression of the membrane of ellipsoid during every tank-tread motion.



Fig. 7: Two cycles of deformation of ellipsoid with damaged membrane during every tank-tread motion.

When the locally damaged point moves along the area of the large curvature, the area might be extended. The extension might deform the ellipsoid to flatten shape (Fig. 7). When the damaged point moves along the area of the small curvature, on the other hand, the extended area might return to the former shape. The shrinkage might deform the ellipsoid to swollen shape.

When the locally damaged point cannot support the moment, the pattern of deformation might change to the reverse pattern. At the small curvature, the membrane receives the larger moment. The ellipsoid might be flattened, when the local defect moves along the area of the small curvature.

The repetitive cyclic deformation might occur, when the damaged point of the membrane locates near the equator of the rotating movement. It might not occur, on the other hand, when the damaged point of the membrane is near the rotational axis. When the damage of the membrane extends, the damaged part might approach to the rotational axis, and the repetitive deformation might be stopped.

The repetitive cyclic deformation may not depend on the turbulence of the flow. Some erythrocytes repeat the cyclic deformation, but others do not. The erythrocytes repeat the cyclic deformation even in the low shear field, after exposure to the high shear stress field. In this case, the damage is irreversible.

The dextran solution was applied to the suspension to inhibit turbulence in the flow with increase of viscosity. Reynolds number (Re) is a useful index for estimation of the turbulent flow.

$$Re = d D v / N \tag{5}$$

In Eq. 5, *d* is density [kg m⁻³] of the fluid, *D* is distance [m] between two parallel disks, *N* is viscosity [Pa s] of the fluid, and *v* is the circumferential velocity of the disk [m s⁻¹].

Re is smaller than 0.006 at *d* (10^3 kg m⁻³), *N* (>0.1 Pa s), *D* (< 10^4 m), and ν (< 6×10^{-3} m s⁻¹) in the present experiment. The number is small enough to inhibit the turbulent flow.

The cone and plate type instrument is used to make uniform Couette type flow [3, 11]. There are several reasons why the parallel disks type is chosen for the rheoscope in the present study. It is easier to make transparent disk with a flat surface. The distance between two disks is uniform, so that it is easier to maintain the distance between disks constant.

The single erythrocyte in the blood is hardly distinguished with microscope, because the volume ratio of erythrocyte in the blood is higher than 0.3. In the present study, erythrocytes are dispersed in the dextran solution to make it easy to be observed as each single cell.

The density of content in cells increases with aging *in vivo*. In the previous study, the younger cells were collected from 10 percent of the supernatant section after centrifugation, where the older cells were collected from 10 percent of the bottom section after centrifugation.

The mechanism of erythrocytes deformability was a target for previous studies [2]. Deformability of erythrocytes might be an index for diagnostics [6]. Both the shear rate and the shear stress govern destruction of erythrocytes in the shear flow [11].

A micro channel could simulate the microcirculation system. The effects of shear flow on cells were observed in the previous studies [12]. The micro-slit is also useful for observation of deformation of a cell.

In the present study, the deformation of erythrocyte is observed in the shear flow to detect the sublethal damage of an erythrocyte with the rheoscope.

5. CONCLUSION

The deformation of an erythrocyte has been observed microscopically in the shear flow to detect the sublethal damage of the erythrocyte *in vitro*. A rheoscope system has been manufactured to observe the deformation of the suspended erythrocytes in the shear flow. The experimental results show that the erythrocytes deform from a biconcave to an ellipsoidal shape and that the erythrocytes with the sublethal damage repeat cyclic deformation at the double frequency of tank tread motion of the membrane.

6. ACKNOWLEDGMENT

The original work was supported by Mr. Shinji Hikita, Mr. Yuki Matsumoto, and Mr. Masayoshi Omori, when they were master course students. This work was supported by a Grant-in-Aid from the Japanese Ministry of Education, Culture, Sports and Technology.

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Micro Hole for Trapping Flowing Cell

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ABSTRACT

Micro holes have been designed to trap a biological cell, which flows through a micro channel in vitro. Several micro traps of a half cylindrical hole of 0.002 mm depth (0.02 mm diameter) have been fabricated on the surface of the polydimethylsiloxane (PDMS) disk with the photolithography technique. A rectangular flow channel (0.1 mm depth \times 1 mm width \times 20 mm length) has been constructed with a silicone film of 0.1 mm thick, which has been sandwiched by two transparent PDMS disks. Two types of biological cells were used in the test alternatively: C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse), or MC3T3-E1 (mouse osteogenic cell line). A constant flow $(2.8 \times 10^{-10} \text{ m}^3/\text{s or } 8.3)$ $\times 10^{-10}$ m³/s) of a suspension of cells was introduced with a syringe pump. The behavior of cells moving over the micro holes was observed with an inverted phase contrast microscope. The results show that the cell is trapped with the micro hole under the wall shear rate less than 100 s^{-1} for several seconds.

Keywords: Biomedical Engineering, C2C12, MC3T3-E1, Micro Trap and Polydimethylsiloxane.

1. INTRODUCTION

Recently, one per three persons dies according to cancer in Japan. A biological cell alters to a cancer cell by an internal or an external factor. The alteration is called "canceration". The cancer cell is out of the control system of the whole body. The cancer cell has several characters: morphological change, infinite proliferation, tumorigenic transformation, and metabasis. Metabasis often causes the cancer recurrence, which leads to patient's death. The tumor permeates through the lymph vessels. The cancer cell transits from the original place to another place, and proliferates to make tumor in another place. The transition occurs through the blood vessels and the lymph vessels. The cancer cells adhere to the endothelial cells, which cover the inner wall of the vessels. The lymph nodes are clinically ablated to avoid metastasis. Wastes and bacteria are transported through the lymph vessel and dissolved at the lymph node. Because the basement membrane of the lymph

vessel is thin enough to take in things, the cancer cell easily metastasizes through the membrane.

The photolithography technique enables manufacturing a micro-channel. The effect of the surface of the scaffold on cell culture has been studied in the previous studies [1-4]. Several micro-fabrication processes have been designed to control adhesion of biological cells *in vitro* [2-8], and to simulate morphology of microcirculation [9]. The micro-fabrication technique has also been applied to design microfluidic systems *in vitro* [10-16]. Cells are rolling on the surface of the wall in the shear flow, and make adhesion to the wall [6]. The surface was modified to capture flowing cells [8, 17, 18]. The technique will also be applied to handle cells in diagnostics *in vitro* [19]. In the present study, micro holes have been designed to trap a biological cell, which flows through a micro channel *in vitro*.

2. METHODS

Micro Traps

Several micro traps of a half cylindrical hole of 0.002 mm depth (Fig. 1) have been fabricated on the surface of the polydimethylsiloxane (PDMS) disk with the photolithography technique (Fig. 2). The diameter of the half cylinder is 0.02 mm. Sixteen holes are arranged in two lines. The interval between holes is 0.02 mm. Variation is made on the direction of the half cylindrical holes (Fig. 3).

A rectangular flow channel has been constructed with a silicone film, which has been sandwiched by two transparent PDMS disks (Fig. 4).

A silicon wafer (Type P, Matsuzaki Seisakusyo, Co., Ltd., Tokyo, Japan) is used for a surface mold for the disk (Fig. 3). The diameter and the thickness of the wafer are 50 mm and 0.30 mm, respectively.

The surface of the wafer is cleaned three times: with the isopropyl alcohol for ten minutes, with hydrogen peroxide solution for ten minutes, and ultrapure water for ten minutes. Then, the wafer was dried on the hot plate (PXW-4, Asahi-rika, Chiba, Japan) at 383 K for 10 minutes, and exposed to the oxygen gas in a reactive ion etching system (FA-1, Samco Inc., Kyoto) to be characterized as hydrophilic (oxygen plasma ashing).

The photo-resist material of low viscosity (SU8-2: Micro Chem Corp., MA, USA) was coated on the wafer with 0.002 mm thick at 2000 rpm for 30 s with a spin coater. The photo-resist was baked on the heated plate with two processes: at 338 K for 1 minute, before at 368 K for 3 minutes.

The pattern of holes (Fig. 3) to make half cylindrical columns on the mold was drawn on the wafer with a laser drawing system (DDB-201K-KH, Neoark Corporation, Hachioji, Japan). To control the dimension of the pattern on the mold with the laser drawing system, the parameters were selected as follows: the voltage of 4 V, the velocity of 0.01 mm/s, the acceleration of 0.5 mm/s². The pattern was baked on the heated plate with two processes: at 338 K for 1 minute, before at 368 K for 3 minutes.

The photo-resist was developed with SU8 developer (Nippon Kayaku Co., Ltd, Tokyo, Japan) for five minutes to make micro columns, where the laser beam was radiated. The wafer was rinsed with the distilled water, and dried on the heated plate. To decrease remaining stress and to increase the adhesiveness of the coating, the wafer was baked at 423 K for 5 minutes.



Fig. 1: Several micro traps in flow channel.



Fig. 2: Photolithography technique.



Fig. 3: Pattern of holes: dimension (mm).



Fig. 4: The flow channel consists of two transparent polydimethylsiloxane (PDMS) disks and a thin silicone rubber sheet.

After development, the dimension of the half cylindrical micro columns on the mold was measured with a laser microscope (VK-X200, Keyence Corporation, Osaka, Japan). The convex mold with micro pattern is used only for the lower disk of PDMS to make the micro holes on the surface.

The surface of the wafer was coated with 0.001 mm thickness of Parylene (Specialty Coating Systems, Inc., IN, USA).

After the wafer is enclosed with a peripheral wall of polyimide, PDMS (Dow Corning Corp., MI, USA) is poured with the curing agent on the wafer. After degassing, PDMS is baked at 353 K for two hours in an oven.

The diameter of two PDMS disks is 50 mm. The thicknesses of the upper and the lower disks are 10 mm and 2 mm, respectively. At the upper disk, two holes of 5 mm diameter (Fig. 4) are machined by a punching tool. The silicone tubes are stuck at the holes without an adhesive.

Flow System

A one-way flow system is designed to control the wall shear rate at the disk of PDMS (Fig. 5) [14]. The system consists of a flow channel, a micro syringe pump, tubes and a microscope (Fig. 6). A plastic tube of 3 mm internal diameter and of 5 mm external diameter is used for the connector to the flow channel. The flow channel consists of two transparent polydimethylsiloxane (PDMS) disks and a thin sheet of silicone rubber.

A thin sheet (0.1 mm thick) of silicone rubber, which has a rectangular void space of 1 mm \times 20 mm, is sandwiched between the PDMS plates (Fig. 4). The void space forms a channel of 20 mm length \times 1 mm width \times 0.1 mm depth. The three plates stick together with their surface affinity without adhesives. The inner surface of the channel was exposed to the oxygen gas in a reactive ion etching system (FA-1, Samco Inc., Kyoto) to be characterized as hydrophilic (oxygen plasma ashing), before assembled.

Immediately after the characterization, the flow path of the chamber was rinsed with a saline solution, and the suspension of cells was introduced, successively.

One of the tubes is connected to the syringe pump (Fig. 6). The room temperature was maintained at 25 degrees Celsius. The chamber is placed on the inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo).

Flow Test

Two types of biological cells were used in the test alternatively: C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse), or MC3T3-E1 (mouse osteogenic cell line, Riken Bio Resource Center, Tsukuba).

C2C12 was cultured with the D-MEM (Dulbecco's Modified Eagle Medium) containing 10% FBS in the incubator for one week. Before the flow test, the cells were exfoliated from the plate of the culture dish with trypsin, and suspended in the D-MEM.

MC3T3-E1 was cultured with the alpha-MEM (alpha modified Eagle's minimal essential medium) containing 10% FBS (fetal bovine serum), in the incubator for one week. The medium also ontains 2.4% of sodium bicarbonate aqueous solution

 $(NaHCO_3, 75 g/L)$ and 1% of Antibiotic-Antimycotic (penicillin, streptomycin and amphotericin B, Life Technologies). Before the flow test, the cells were exfoliated from the plate of the culture dish with trypsin, and suspended in the alpha-MEM.

The suspension was introduced to the chamber at the constant flow with the micro syringe pump. Variation was made on the flow rate: $2.8 \times 10^{-10} \text{ m}^3/\text{s}$ and $8.3 \times 10^{-10} \text{ m}^3/\text{s}$.

The flow path was carefully examined to avoid mixing of air bubbles, which might stir the medium in the flow channel. The behavior of cells moving over the holes in the channel was observed with the microscope.



Fig. 5: Flow test system: flow chamber and microscope (middle), syringe pump (right).



Fig. 6: Flow to syringe pump through flow chamber.



Fig. 7: Parabolic velocity profile between parallel plates.

Shear Rate on Wall

The shear rate $(G, [s^{-1}])$ on the wall of the disk is calculated by Eq. 1, in which a parabolic velocity profile between parallel plates is hypothesized (Fig. 7).

$$G = 6 q / (b D^2) \tag{1}$$

In Eq. 1, q is the flow rate [m³ s⁻¹], b is the width of the canal [m] and D is distance [m] between two parallel walls. In the present study, D is 0.1 mm, and b is 1 mm (Fig. 7). The wall shear rate G varies from 35 to 100 per second, when the flow rate q varies from 2.8 ×10⁻¹⁰ m³/s to 8.3 ×10⁻¹⁰ m³/s.

3. RESULTS

The laser measurement of surface morphology of the mold shows that the diameter of half cylindrical column is 0.02 mm, as the designed dimension. The laser measurement also shows that the mean height of micro columns is 0.0015 mm (Fig. 8).

The flow tests show the following results.

The moving cells over the holes are able to be observed with the microscope in the flow test system. The diameter of the suspended cell is approximately 0.01 mm. The trapped time of the cell is measured compared with the movement of floating cell.

In the case of C2C12, one of the cells is trapped in the hole for 5 seconds in the flow rate of 2.8×10^{-10} m³/s (Fig. 9). Another cell is trapped in the hole for 8 seconds in the flow rate of 8.3 $\times 10^{-10}$ m³/s (Fig. 10).



Fig. 8: Laser measurement of morphology of convex column at surface of the mold. Cross section at line A-B (bottom).

In the case of MC3T3-E1, one of the cells is trapped in the hole for one second in the flow rate of 2.8×10^{-10} m³/s (Fig. 11). Every cell rolls over the hole in the flow rate of 8.3×10^{-10} m³/s (Fig. 12).

The time of trapped in the hole is longer with C2C12 than with MC3T3-E1.



Fig. 9: C2C12 in red lower circle approaches to the hole (upper left), enters (upper right), is trapped for 5 s (lower left), and exits (lower right). Flow $(2.8 \times 10^{-10} \text{ m}^3/\text{s})$ from right to left.



Fig. 10: C2C12 enters (left), is trapped for 8 s (middle), and exits (right). Flow $(8.3 \times 10^{-10} \text{ m}^3/\text{s})$ from right to left.



Fig. 11: MC3T3-E1 in red small circle approaches to the hole (upper left), enters (upper right), is trapped for 1 s (lower left), and exits (lower right). Flow $(2.8 \times 10^{-10} \text{ m}^3/\text{s})$ from right to left.



Fig. 12: MC3T3-E1 in red small circle approaches to the hole (left), is on the hole (middle), exits from hole (right). Flow $(8.3 \times 10^{-10} \text{ m}^3/\text{s})$ from right to left.

4. DISCUSSION

The photolithography technique has been applied to fabricate the micro channel. The microfluidic system has been applied to sort biological cells [13], and to trap biological cells [14, 17, 18]. The system also used to study local environment around the cultured cell [1, 4]. The micro pattern of the surface has been applied to study the surface effect of adhesion of cells [2, 3].

The morphology of micro channel has simulated the lymph system in the circulatory system *in vivo*. In several studies, permeability has been tried to control in designing artificial vessels. The experimental results might contribute to analyze adhesive mechanism of cancer cell during metastasis. The micro trap might simulate adhesive mechanism of flowing cells.

In the previous study, cylindrical holes were used for trap of cells. The half cylindrical holes are designed in the present

study. The asymmetrical hole might be suitable for trap than symmetrical hole.

The depth of the micro holes was 0.01 mm in the previous study [8]. In the present study, the depth of the micro holes of 0.002 mm is smaller than diameter of the cells. The deeper hole may have advantage to trap cells. The shallow trap, on the other hand, may distinguish cells. The duration of the trapped time of the cell might relate to interaction between the micro hole and the cell: adhesiveness between the cell and the surface of the micro pattern, or deformability of the cell.

Behavior of biological cells might depend on several factors: magnetic field [20], electric field [21], or mechanical field [22-24].

5. CONCLUSION

Micro holes have been designed to trap a biological cell, which flows through a micro channel *in vitro*. Several micro traps of a half cylindrical hole of 0.002 mm depth (0.02 mm diameter) have been fabricated on the surface of the polydimethylsiloxane (PDMS) disk with the photolithography technique. Two types of biological cells were used in the experiment alternatively: C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse), or MC3T3-E1 (mouse osteogenic cell line). The experiments show that the cell is trapped with the micro hole under the wall shear rate less than 100 s⁻¹ for several seconds.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Communication Training for Students in Multidisciplinary Research Area of Biomedical Engineering

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ABSTRACT

"Biomedical Engineering" makes multidisciplinary research area, which includes biology, medicine, engineering and others. Communication training is important for students, who have a "Biomedical potential develop Engineering". to Communication is not easy in a multidisciplinary research area, because each area has its own background of thinking. Because each nation has its own background of culture, on the other hand, international communication is not easy, either. A cross-cultural student program has been designed for communication training in the multidisciplinary research area. Students from a variety of backgrounds of research area and culture have joined in the program. The program works well for communication training in the multidisciplinary research area of biomedical engineering. Foreign language and digital data give students chance to study several things: how to make communication precisely, how to quote previous data. The experience in the program helps students not only understand new idea in the laboratory visit, but also make a presentation in the international research conference. The program relates to author's several experiences: the student internship abroad, the cross-cultural student camp, multi PhD theses, various affiliations, and the creation of the interdisciplinary department.

Keywords: Communication Training, Multidisciplinary Research Area, Biomedical Engineering, Training for Students and Cross-cultural Program.

1. INTRODUCTION

Communication conveys information. Engineering is research field to be applied to the society. Preciseness is important for the communication in engineering to be applied to the society.

Communication is realized through various networks: face to face conversation, letters, drawings, telephones, electrical networks.

Misunderstanding often occurs in a multidisciplinary research area, because each area has its own background of thinking.

A common base is necessary for communication. Similar experiences develop the common base. When common rules are defined, the communication becomes easier. That is the reason why you learn language, mathematics, SI unit, etc.

The biomedical engineering field is multidisciplinary [1-9]. That includes various fields: biology, medicine, pharmacy. In the field, communication is important between engineering and medicine.

In an international project, you may experience misunderstandings, which depend not only on the language, but also on the cultural background. In a research project in the interdisciplinary field, you also experience misunderstandings, which depend on the methodological backgrounds. In this point of view, both international projects and interdisciplinary projects have the common problem. The problem supplies a good chance for communication training.

Digital culture gives us useful tool of copy. We can easily access to large amount of previous data through internet. Student should learn right way to use these tools.

In the present study, a cross-cultural student program has been designed for communication training in the multidisciplinary research area.

2. METHODS

Group Activity and Presentation Competition

The annual cross-cultural student program of Biomedical Engineering in Thailand has been started in 2011 [8, 9]. The theme was "Oil dispersed over the ocean by an accident of a tanker" last year. Students, who participate in the program, divided into several groups. Each group has to make a report on the theme, and to make a presentation at the final session. Two days are available to make the report and to prepare for the presentation.

Students are allowed to use internet to check information. They can use personal computer to make the report, and to make slides for presentation.

Laboratory Visit

Several universities have special programs on biomedical engineering in the world. The author has communicated with several coordinators of the programs. Some of them supported to create a new department of biomedical engineering in Japan in 2006 [1-7]. Some of them agree to collaborate with our group. Some of them have welcomed our student, and exchanged idea in the annual laboratory visit since 2008 [8, 9].

Presentation in International Research Conference

Students have attended the annual international multidisciplinary research conference, and made the oral presentation since 2004 [8, 9].

3. RESULTS

Group Activity and Presentation Competition

In 2013, fifteen students from Thailand (includes international students) and ten students from Japan joined in the seminar. Their backgrounds are mechanical engineering, material science, environmental engineering, science of nursing, dentist, pharmacy, and electronics. In each group students discuss on the issue, pickup agenda, and adjust the process to make a final report of the group. Students exchange idea in each group (Fig. 1).

One student designs special machine to collect oil. Some students propose biological method to collect the oil. Another student proposes chemical method to change the material. Some students evaluate an economical aspect to the proposal.

They were able to translate English to their own native language at the internet. They easily found data on the internet (Fig. 2). They made slide with data, which is available on the web side.

Several groups made presentation with slides (Fig. 3). In the slides, they used figures, which they found on the web. In one group, a member used white board to write figures by himself (Fig. 4).

It was the first experience for Japanese students to make a group activity in English. The evaluation to their English was not very good, but the presentation of every Japanese student was understandable to Thai students. The figures in the slides might help for Thai students to understand the outline. The presentation is good training for the students to explain contents in the logical order.

The presentation also gave a Japanese student a good opportunity to express himself to the person of the first meeting. After the seminar, communication among students continues to the sightseeing in the traditional places (Figs. 5 & 6). Some students keep in touch with the participants by e-mail.

Laboratory Visit

In 2013, ten students visited two universities in Thailand, and four students visited two universities in USA.

It was not easy for Japanese students to understand the lecture in English (Figs. 7-9).

Several research projects in biomedical engineering were introduced to Japanese students. The topic was familiar to Japanese students, because they knew the instruments. Students exchanged ideas about the experimental system.

Presentation in International Research Conference

Four students made oral presentation last year (Fig. 10). The topics are as follows:

- 1) Behavior of Cells through Micro Slit
- 2) Effect of Mechanical Stimulation on Orientation of Cultured Cell

- 3) Micro Trap for Flowing Cell
- 4) Effect of Micro Ridges on Cell Culture
- 5) Observation of Biological Cells in Rhombus Parallelepiped Flow Channel
- 6) Finite Element Analysis of Bone Remodeling: Resident's Ridge Formation in Femoral Condyle

Several students made poster presentation in the international symposium last year (Fig. 11).



Fig. 1: Group discussion.



Fig. 2: Slide preparation with internet.



Fig. 3: Presentation with slides.



Fig. 4: Presentation with writing on board.



Fig. 5: Cross-cultural student program.



Fig. 6: Cross-cultural student program.



Fig. 7: Laboratory visit.



Fig. 8: Laboratory visit.



Fig.9: Laboratory visit.



Fig. 10: Oral presentation in international conference.



Fig. 11: Poster presentation in international conference.

4. DISCUSSION

Reproducibility

Reproducibility is important in the Science field. A result should be repeatable in the same condition. The result is confirmed, when the same result is realized with the following trial. Science is not magic. The condition should be disclosed to realize the same result by another trial.

In biology, on the other hand, it is not easy to confirm repeatability, because the same condition is hardly controlled. In biology, everything is variable, and never repeats same situation.

References

Finding is new, and nobody knows before. It is original, of course.

Design is created by someone, so that design has a previous origin, elsewhere. Design should be related to references, even if it is created through revolution. References help the design in several aspects. They identify the position of the design in previous things. They show relation to another thing. They confirm the value. They help idea to be realized.

Reference should be quoted as that was existed. It should not be modified at all. It should be the same as the original.

Reference should be listed with enough information for someone to seek for the reference. If the information has been edited several times, the number of edition should also be listed. Do not quote like the way as telephone game or ear-duster. References are also effective for new findings, although you have to be careful for plagiarism.

Digital Data

Digitized data decrease ambiguity of analog data. Digital data are easily not only copied, but also modified. Digital data include not only text, but also figures. The figure made of digital data is easily modified: color, brightness, size, rotation, and so on (Figs. 12 & 13).

How should we use the function of copy in the digital culture. We should copy from original data. Do not give misunderstanding. We should identify the source. Adding arrow and scale bar would be allowed.

Although art should be original and creative, science is not art. The method to transmit the information should be universal. If the information is described in unique way, the information is not understandable for another person.

The information should be available to everyone, and attribute to society. For universal communication, mathematics is useful. A unit has been developed. Description should be logical.



Fig. 12: Modification of digital data: original (A), bigger size (B), ratio changed (C), color (D), brightness (E), rotation (F).



Fig. 13: Modification of digital data: original (A), ratio changed (B), contrast changed (C), additional arrow and scale bar (C).

Foreign Language

In one's own native language, communication is easier. A large amount of vocabulary can be used. In the native language, people feels nuance. The same background allows using abbreviations. It is not good for preciseness of communication. Be careful at symbols, which have different meaning according to its background.

It is not easy for foreigner to create original sentence in English. It is good training for logical expression. Grammatical check is not enough. Preciseness is necessary. Nuance is not necessary. Technical term is important. Each field has rule for expression. Author has better to follow the rule. Author may copy the expression in the same special field of study.

The note of experiment is important: it is precise record of protocol for oneself to memory for the next experiment.

Recently, we have a lot of tools for communication. Although the e-mail system is very convenient for communication, communication on face to face has more information than digital signals: movement, atmosphere, and many expressions. Letters can reveal feeling by handwriting. A telephone can give a tone of the voice. A handshake tells temperature, and the force of the muscle. Paying attention to the background is important for communication training. You may be surprised if some language systems do not have a term, which means "Reflection". The culture might be positive.

At the beginning, students tend to pay attention to the language itself. After the seminar, students found: "it is easy to find the rule, but difficult to understand the background".

"Biomedical Engineering" is a multidisciplinary field of study, which relates to engineering and medicine [2].

When I was a student, I experienced a technical internship in the institute of artificial heart in Free University Berlin. The research project of the artificial heart had been supported by collaboration between engineering and medicine. The experience gave me international sense and interdisciplinary sense, simultaneously.

I myself joined the cross cultural student camp every year, since I was nineteen years old. I experienced a lot of difficulties to communicate with students of different field of study, and of different background of culture.

I found different disciplines, when I take examinations for multiple PhD theses: one for medicine and the other for engineering. The research in the field of biology is based on individuality and time dependent, so that statistical processing is indispensable. The research in the field of engineering is based on homogenization, so that the experimental condition should be controlled. The referee of medicine requested number of experiment with keeping the protocol, although the referee of engineering requested the sophisticated condition of the experiment.

I also found different disciplines, when my affiliation changed: school of medicine, electronics, biomedical engineering and mechanical engineering. Each special field of study develops own discipline including the style of education. Each discipline has one's own technical terms. For example, "control" means "comparison" in medicine and "regulation" in engineering, respectively.

Creating the first department of "Biomedical Engineering (including bachelor, master, and PhD courses)" in Japan was a big challenge (Fig. 11). I created a new concept for the interdisciplinary department [1-7].

The multidisciplinary field makes students learn several things: logical thinking, and flexibility without prejudice. The common background of "Biomedical Engineering" helps them find a way of thinking.

The shocking experience of the cross cultural seminar makes students notice "It is important to understand the background of thinking to learn the multidisciplinary field of study". Most of students continue their research activity to the post graduate course.

5. CONCLUSION

A cross-cultural student program has been designed for communication training in the multidisciplinary research area. Students from a variety of backgrounds of research area and culture have joined in the program. The program works well for communication training in the multidisciplinary research area of biomedical engineering. The experience in the program helps students not only understand new idea in the laboratory visit, but also make a presentation in the international research conference.

ACKNOWLEDGMENT

Author is thankful to Dr. Mana Sriyudthsak of Chulalongkorn University, Dr. Jackrit Suthakorn of Mahidol University, Prof. Robert A. Linsenmeier of Northwestern University, to Prof. Richard L. Magin of University of Illinois at Chicago, for collaboration to our project.

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Behavior of Cell Passing through Micro Slit

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ABSTRACT

Behavior of a biological cell passing through a micro slit has been observed *in vitro*. The photolithography technique enables manufacturing the micro slit. A silicone disk is used for a mold, and a dry etching process is applied for the micro-fabrication. The slit, of which width is 0.85 mm and height is 0.001 mm, has been designed between two parts of transparent polydimethylsiloxane disks, which have micro ridges. The suspension of swine red blood cells or C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) has alternatively been introduced to the slits by drawing with a syringe pump. The behavior of cells passing through the micro slit has been observed with an inverted phase-contrast microscope. The experimental results show that several red blood cells can pass through the micro slit, although C2C12 cannot pass through the micro slit.

Keywords: Biomedical Engineering, Red Blood Cell, C2C12, Photolithography and Micro-slit.

1. INTRODUCTION

An erythrocyte has flexibility [1] and deforms in the shear flow [2, 3]. It also passes through micro-circulation, of which the dimension is smaller than the diameter of the red blood cell. After circulation through the blood vessels for days, the red blood cell is trapped in the micro-circulation systems.

One of the systems, which trap red blood cells, is a spleen. The spleen has special morphology in the blood flow path to sort injured red blood cells [4-6].

The photolithography technique enables manufacturing a micro-channel [7-9]. Several micro-fabrication processes have been designed to simulate morphology of microcirculation. The technique also will be applied to handle cells in diagnostics *in vitro* [10].

In the present study, micro slits have been designed to control behavior of biological cells *in vitro*.

2. METHODS

Micro Slits

The slit, of which width is 0.85 mm and height is 0.001 mm, has been designed between two parts of transparent polydimethylsiloxane disks (Figs. 1 & 2). They have micro ridges. The lower part has three ridges of 0.001 mm height (0.1 mm width, 1 mm length) with the interval of 0.85 mm. The upper part has a ridge of 0.057 mm height: 0.05 mm width and 2 mm length (Fig. 3). These ridges make contact each other in the perpendicular position, and make slits between the ridges.

Mold Base

A silicon wafer (Type P, Matsuzaki Seisakusyo, Co., Ltd., Tokyo, Japan) is used for a surface mold for the disk. The diameter and the thickness of the wafer are 50 mm and 0.30 mm, respectively.

The surface of the wafer is cleaned three times in an ultrasonic cleaner: with 2-propanol for five minutes, with hydrogen peroxide solution for five minutes, and with ultrapure water for five minutes. Then, the wafer was dried with an air gun.



Fig. 1: Channel with slit.



Fig. 2: Cross-section view of slit: A-A' in Fig.1.



Fig. 3: Dimension of micro ridges: upper (left), lower (right).

Photolithography

The photo-resist material of OFPR-800 (Tokyo Ohka Kogyo Co., Ltd, Tokyo, Japan) was coated on the wafer with 0.002 mm thick at 5000 rpm for 30 s with a spin coater. The photo-resist was baked on the heated plate at 383 K for 90 s.

The pattern of ridges (Fig. 3) was drawn on the wafer with a laser drawing system (DDB-201K-KH, Neoark Corporation, Hachioji, Japan). The width of the trace of laser is proportional to the voltage, although the width is inversely proportional to the velocity. To control the dimension of the ridges of the mold with the laser drawing system, the parameters were selected as follows: the voltage of 3 V, the velocity of 0.1 mm/s, the acceleration of 0.5 mm/s².

The photo-resist was developed with tetra-methyl-ammonium hydroxide (NMD-3, Tokyo Ohka Kogyo Co., Ltd., Kawasaki, Japan) for several minutes. The wafer was rinsed with the distilled water, and dried with the air gun. To increase the adhesiveness of the coating, the wafer was baked at 383 K for 5 minutes.

The wafer was etched with the plasma gas using Si Deep RIE System (MUC-21 ASE-SRE, Sumitomo Precision Products Co., Ltd., Amagasaki, Japan) to make the micro grooves. On the lower disk, the gas of SF₆ (50 cm³/min at 1013 hPa) with O₂ (25 cm³/min at 1013 hPa) and with Ar (25 cm³/min at 1013 hPa) was applied at 50 W at 10 Pa for five minutes. On the upper disk, the switching mode between C₄F₈ gas and SF₆ gas was applied.

The residual photo-resist was exfoliated in the separating solution (Hakuri 105, Tokyo Ohka Kogyo Co., Ltd, Kawasaki, Japan). The wafer was dipped in 2-propanol, before rinsed with the distilled water. Then, the wafer with the grooves was dried with the air gun, and used for the concave mold to make micro convex ridges in the following process. The dimension

of the grooves on manufactured mold without coating was measured with the laser microscope (VK-X200, Keyence Corporation, Osaka, Japan).

PDMS Disk

The surface of the wafer with micro pattern was coated with 0.001 mm thickness of parylene in the parylene coater (PDS-2010, Speciality Coating Systems, Indianapolis). After the wafer was enclosed with a peripheral wall of polyimide, PDMS (Sylgard 184 Silicone Elastomer Base, Dow Corning Corporation) was poured together with the curing agent (Dow Corning Corporation) on the wafer. The volume ratio of curing agent is ten percent of PDMS. The volumes of PDMS are 4.4 cm³ for the upper disk and 2.2 cm³ for the lower disk, respectively.

After degassing, PDMS was baked at 383 K for one hour in an oven (DX401, Yamato Scientific Co., Ltd). The baked disk of PDMS is exfoliated from the mold. The dimension of the ridges on manufactured PDMS was measured with the laser microscope.

Flow Test System

A one-way flow system was designed to observe the behavior of cells through the micro slits *in vitro* (Fig. 4). The system consists of a flow chamber, a syringe pump, tubes and a microscope. The micro-syringe-pump (Fusion200, CXF1020, ISIS Co., Ltd., Osaka) was used for the syringe pump. A plastic tube of 3 mm internal diameter and of 5 mm external diameter was used for the connector to the flow chamber.

The flow chamber consists of two transparent polydimethylsiloxane (PDMS) disks and a thin sheet of silicone rubber (thickness of 0.05 mm, ARAM Corporation, Osaka) (Fig. 1).

A rectangular open space of 2 mm \times 30 mm is cut off in the sheet, and sandwiched between the PDMS plates. The open space forms a channel of 30 mm length \times 2 mm width \times 0.05 mm depth.

The three parts stick together with their surface affinity without an adhesive. The diameter of two PDMS plates is 50 mm. The thicknesses of the upper and the lower disks are 4 mm and 2 mm, respectively.

The PDMS disk, which has three micro columns on the upper surface, was placed in the bottom. The upper PDMS disk has one micro column on the lower surface, and has two holes of 5 mm diameter machined with a punching tool. The silicone tubes are stuck at the holes with an adhesive for the inlet and the outlet. The assembled disks are contained on the polystyrene dish of 70 mm diameter and the circumferential crevice between the parts is filled with adhesive from outside (Fig. 4).

Flow Test

Two kinds of cells were used in the flow test: C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse), and swine red blood cells.

In the case of C2C12, cells were suspended in the medium of D-MEM (Dulbecco's Modified Eagle's Medium) with the density of the cells 15000 cells/cm³, and pumped at flow rate of 0.005 cm^3 /hour.



Fig. 4: Flow system: channel and microscope.

Swine red blood cells in sodium acid citrate aqueous solution (ACD-A, Terumo Corporation, Japan) were used after preservation in a refrigerator for two days. After centrifugation of the swine blood, the red blood cells were separated from plasma. The cells were suspended in the phosphate buffer solution to make a suspension of red blood cells at the volume ratio of 0.05 percent.

The movement of cells near the slits was observed with an inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo), while the suspension of cells was pumped at the flow rate of 0.003 cm³ /hour at 298 K (Fig. 4). In the flow path of depth of 0.05 mm (width of 2 mm), the flow rate makes mean velocity of 0.08 mm/s.

3. RESULTS

Fig. 5 shows the manufactured slit observed with the inverted microscope. Cells flow from left to right over the vertical ridge (0.05 mm height). The horizontal ridge crossing perpendicularly to the vertical ridge makes the slit between vertical ridge and the surface of the lower disk.

Fig. 6 exemplifies the dimension of the groove on the manufactured mold of the lower part measured by the laser microscope. The width and the length are 0.1 mm and 1 mm, respectively. The tracings of the depth along the three lines (Fig. 6(A)) and the cross section (Fig. 6(B)) of the groove show slightly scattered values around the mean value of 0.00088 mm. Fig. 7 exemplifies dimension of the groove of the upper parts. The tracings of the depth along the three lines of the groove show slightly scattered values around the mean value of 0.053 mm.

Figs. 8 & 9 exemplify dimension of the ridges on the manufactured lower and upper parts measured by the laser microscope, respectively. The mean values of the height are 0.0011 mm and 0.055 mm, respectively. The mean value of thickness of the sheet of silicone rubber measured by the laser microscope is 0.057 mm.

Figs. 10-12 exemplify the red blood cell passing through the slit. The cell flows from left to right. The velocity of the cell moving through the slit is not accelerated compared with the decrease of cross section of the flow path. Fig. 13 exemplifies C2C12 approaching to the slit. C2C12 was not able to pass through the slit.



Fig. 5: Micro slit. Cells flow from left to right under vertical ridge (0.05 mm height). Horizontal ridge has 0.001 mm height (1 mm length, 0.1 mm width).



Fig. 6(A): Dimension of groove on manufactured mold of lower part measured by laser microscope: tracings of cross section shows mean depth of 0.00088 mm.

4. DISCUSSION

In the present study, the micro slit has been designed with narrower dimension than the previous study [11] to observe the deformation of cells or to trap some red blood cells in the present study (Fig. 14). Deformation has not been observed while the red blood cell is passing through the slit. The low velocity of the red blood cell might show the friction between the wall of the slit and the cell during movement.



Fig. 6(B): Dimension of groove on manufactured mold of lower part measured by laser microscope: top view (upper), and tracings (lower) of cross section between 2 to 2' (upper), which shows mean depth of 0.00088 mm.



Cross-section of three lines

Fig. 7(A): Dimension of groove on manufactured mold of upper part measured by laser microscope: tracings of cross section shows mean depth of 0.053 mm.

The dimension of the slit might be extended during the assembly process of two disks so that most of red blood cells pass through the slit.

The fine architecture of the red pulp of the spleen has been investigated in the previous studies [4-6]. The continuity between capillaries and splenic sinuses has been examined with the microscope. The special morphology might relate to the function for sorting erythrocytes.



Fig. 7(B): Dimension of groove on manufactured mold of upper part measured by laser microscope: top view (upper), cross section (middle) shows mean depth of 0.053 mm, threedimensional view (lower).



Top view

Cross-section of three lines

Fig. 8(A): Dimension of ridge on manufactured lower part measured by laser microscope: mean height is 0.0011 mm.





Fig. 8(B): Dimension of ridge on manufactured lower part measured by laser microscope: mean height is 0.0011 mm.



Cross-section of three lines



(Cross-section perpendicular to longitudinal direction)

Fig. 9: Dimension of ridge on manufactured upper part measured by laser microscope: mean height is 0.055 mm.

In the previous studies, the typical diameter of the micro channel, which simulates the capillary blood vessel, is around 0.005 mm [8]. The red blood cell, on the other hand, passes through micro slit narrower than 0.001 mm in the spleen. The small dimension of passage has been applied to biological cells in the present study.



Red blood cell

Fig. 10: Red blood cell approaches to slit. Flow from left to right. The bar shows 0.02 mm.



Red blood cell

Fig. 11: Red blood cell passing through slit. Flow from left to right. The bar shows 0.02 mm.



Red blood cell

Fig. 12: Red blood cell passed through micro slit. Flow from left to right. The bar shows 0.02 mm.



Fig. 13: C2C12 approaches to slit. Flow from right to left. The bar shows 0.1 mm.



Red blood cell passing through slit

Fig. 14: Deformed cell might pass through slit.

The effect of flow on cells has been investigated in the previous studies [12, 13]. A micro channel could simulate the microcirculation system. Fatigue of erythrocyte was evaluated through the narrow path [14, 15]. To simulate the microcirculation system with a fabricated channel, the three dimensional curvature of the wall of the flow channel might be important. Cells are responsive to the micro morphology of the scaffold. The micro groove governs the behavior of cells.

The micro-slit is, on the other hand, useful for treatment of cell in diagnostics [10]. The micro-channel devices may contribute to the development of biotechnology.

5. CONCLUSION

The behavior of a biological cell through a micro slit has been observed *in vitro*. The slit, of which width is 0.85 mm and height is 0.001 mm, has been designed between two parts of transparent polydimethylsiloxane (PDMS) disks. The suspension of swine red blood cell, or C2C12 has been introduced to the slits, and the movement of cells has been observed with a microscope. The experimental results show that several cells can pass through the micro slit.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Effect of Centrifugal Force on Cell Culture

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ABSTRACT

An effect of a mechanical force field on cell culture has been studied *in vitro*. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was cultured on a polystyrene plate coated with collagen for 13 days in the mechanical force field. To apply the mechanical force field to the cells on the plate, the plate was inserted into a centrifugal tube. The tube was placed in a conventional centrifugal machine, to set the surface of the culture plate in the parallel position to the centrifugal field. The shape and the orientation of the cells were observed with a phase contrast microscope during the cell culture. The experiments show that C2C12 extends pseudo, proliferates to the confluent manner and differentiates to myotube even under continuous stimulation of 270 times of the gravitational force.

Keywords: Biomedical Engineering, C2C12, Cell Culture and Centrifugal Force Field.

1. INTRODUCTION

Cell culture technique has been developed and several methodologies have been clinically applied to regenerative medicine. The acceleration technique for orientation, proliferation and differentiation of cells has been studied to make tissue *in vivo* or *in vitro* [1-9, 12]. Control methodology for orientation, proliferation and differentiation of cells would be applied to the regenerative tissue technology.

The mechanical stress is one of the interested factors in the environment of cells, because they receive mechanical force *in vivo*. The mechanical stress on cells might induce various responses: deformation, migration, proliferation, and differentiation. Several methods have been designed to apply the mechanical stress to cells [2-10, 16].

A transmission point of the stress to a specimen is important. In many studies, the stress is applied to a scaffold [2-5]. When fixation between the cell and the scaffold is not enough, the stress is not transmitted to the cell. A mechanical field, on the other hand, can be used to apply a continuous stress to a specimen [6-10, 13]. The specimen fixed at a position receives the shear stress in the mechanical field.

The biological cells receive gravitational force on the earth. An astronaut needs exercise before standing, when he comes back from the space station. The characteristic of muscle tissue might change in the space station, where the tissue does not receive gravitational force [11].

In the present study, the effect of mechanical stimulation on cultured cells has been studied in centrifugal force field *in vitro*.

2. METHODS

Excess Gravitational Force Field

The excess gravitational force was applied to cultured cells with the centrifugal force (Fig. 1). Cells were cultured on a polystyrene plate (30 mm \times 8.5 mm \times 2 mm) for two weeks in the centrifugal force field. The plate has a line on the back side of the culture surface to mark the observation point. To apply the mechanical force field to the cells on the plate, the plate was inserted into a centrifugal tube. The tube (Fig. 3) was set on an angled rotor in the centrifugal machine (CN-1040, Matsuuraseisakusyo. Ltd, Tokyo, Japan) (Fig. 4). The rotor (turning radius of 8 cm) was rotated with the constant speed slower than 1750 revolutions per minute, which makes the excess gravitational force lower than 270 G at the surface of the The angle between the directions of the culture plate. centrifugal force and the surface of the cell culture plate is 1 rad. The force is divided into two ingredients, which are the tangential force and the normal force at the culture plate. The centrifugal force of 270 G makes 140 G of the tangential force and 230 G of the normal force. To keep the balance of the rotator in the centrifugal machine, two tubes were placed in the counter position each other. The centrifugal machine was placed in an incubator to keep the partial pressure of bicarbonate of 5 % at 310 K. The tube is shield with Parafilm (Pechiney Plastic Packaging Company, IL), through which gas passes. For comparison, some tubes were shield with the plastic screw cap.

Cell Culture

C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) of the passage between the third and the sixth was used in the test. C2C12 was cultured with the D-MEM (Dulbecco's Modified Eagle Medium) containing 10% FBS. The medium containing penicillin and streptomycin was refreshed every two days.







Fig. 2: Cell culture in tube. Mark to trace the same area of culture.



Fig. 3: Centrifugal machine in incubator.



Fig. 4: Electrodes for stimulation.

The polystyrene plate cut from the bottom of a culture dish is dipped for 24 hours in ethanol for disinfection. After rinsed with a phosphate buffer solution, the plate was placed in the culture dish of six wells, and the cells were seeded at the density of 3000 cells/cm². After the cells were cultured for 24 hours without centrifugal stimulation, the plate was moved from the dish to the tube and exposed to mechanical stimulation of the centrifugal force for two weeks. The medium was changed every two days.

Morphological Study

Density and morphology of cells was observed with an inverted phase-contrast microscope (IX71, Olympus, Tokyo) every 24 hours during the test. During the observation, the rotation of the centrifugal machine was stopped, and the plate with cells was moved from the tube to the dish filled with the medium.

Electric Stimulation

At the end of tests, myotubes were stimulated with electric pulses to confirm differentiation of C2C12. The culture plate was moved from the tube to the dish. The electric pulse (interval shorter than 0.5 s, amplitude lower than 25 V, duration 0.002 s) was generated with an electric stimulator (SEN5201, Nihon Kohden Corporation, Japan). The pulses were applied with a couple of electrodes of platinum wire of 0.1 mm diameter, which was dipped into the medium of the culture dish (Fig. 4). The movement of the myotubes was observed with the inverted phase-contrast microscope.

3. RESULTS

The experiments show the following results.

Cells deform from the round shape to the extended shape, which shows adhesion on the culture plate in 24 hours (Fig. 5(A)). The cells are sparse on the plate, because most of cells adhere to the bottom of the dish.

C2C12 begins to fuse to make myotube after centrifugation sealed with the cap for one day at 5.6 G (Fig. 5(B)). Centrifugal force is downward direction in the following figures. Myotubes are oriented not only to the parallel direction to the centrifugal force field, but also perpendicular direction to the centrifugal force field. Most of cells are exfoliated after centrifugation sealed with the cap for four days (Figs. 5(C)&(D)). The result at 89 G (Fig. 6) is similar to that at 270 G (Figs. 7(C), 8(C), 9(C)).



Fig. 5(A): C2C12 before centrifugation of 5.6 G (250 rpm) with cap for 24 hours. Dimension from left to right is 2 mm.



Fig. 5(B): C2C12 after centrifugation at 5.6 G for one day. Centrifugal force is downward direction in the following figures.



Fig. 5(C): C2C12 after centrifugation of 5.6 G with cap for two days. Dimension from left to right is 2 mm.



Fig. 5(D): C2C12 after centrifugation of 5.6 G with cap for four days. Dimension from left to right is 2 mm.



Fig. 6(A): C2C12 before centrifugation of 89 G with cap for 24 hours. Dimension from left to right is 2 mm.



Fig. 6(B): C2C12 after centrifugation of 89 G with cap for one day. Dimension from left to right is 2 mm.



Fig. 6(C): C2C12 after centrifugation of 89 G with cap for two days. Dimension from left to right is 2 mm.



Fig. 6(D): C2C12 after centrifugation of 89 G with cap for four days. Dimension from left to right is 2 mm.



Fig. 7(A): C2C12 before centrifugation of 270 G with film for 24 hours. Dimension from left to right is 2 mm.



Fig. 7(B): C2C12 with film for 24 hours. Dimension from left to right is 2 mm.



Fig. 7(C): C2C12 before centrifugation of 270 G with cap for 24 hours. Dimension from left to right is 2 mm.



Fig. 7(D): C2C12 with cap for 24 hours. Dimension from left to right is 2 mm.



Fig. 8(A): C2C12 after centrifugation of 270 G with film for 4 days. Dimension from left to right is 2 mm.



Fig. 8(B): C2C12 with film for 4 days. Dimension from left to right is 2 mm.



Fig. 8(C): C2C12 after centrifugation of 270 G with cap for 4 days. Dimension from left to right is 2 mm.



Fig. 8(D): C2C12 with cap for 4 days. Dimension from left to right is 2 mm.



Fig. 9(A): C2C12 after centrifugation of 270 G with film for 12 days. Dimension from left to right is 1 mm.



Fig. 9(B): C2C12 with film for 12 days. Dimension from left to right is 2 mm.



Fig. 9(C): C2C12 centrifugation of 270 G with cap for 12 days. Dimension from left to right is 2 mm.



Fig. 9(D): C2C12 with cap for 12 days. Dimension from left to right is 2 mm.



Fig. 10: Medium after two days of cell culture: centrifugation with film (A), rest with film (B), centrifugation with cap (C), rest with cap (D).

When the tube sealed with the film, C2C12 proliferate to the confluent manner and differentiates to myotube even under continuous stimulation of 270 times of the gravitational force for 12 days (Figs. 7(A), 8(A), 9(A)).

Without excess gravitational force, C2C12 proliferate to the confluent manner and differentiates to myotube even sealed with cap (Figs. 7(D), 8(D), 9(D)).

C2C12 differentiates to myotube. The repetitive cyclic constriction of the myotube is observed in 13 days of culture, when the electric pulses are applied to the medium (Fig. 9(A)).

In two days of cell culture, the color of the medium in the tube sealed with the cap does not change much (Fig. 10(C&D)), although that in the tube sealed with the film changes (Fig. 10(B)).

4. DISCUSSION

The culture plate of polystyrene is cut from the bottom of the culture dish, because the material is standard in the cell culture. Even after dipped in ethanol, C2C12 is proliferated and differentiated on the plate.

The response of biological system to the microgravity field has been studied using a space satellite. The cell cycle might extend in the space. C2C12 differentiation might be accelerated and the myotube might align to the direction perpendicular to the centrifugal field in the atmospheric partial pressure [7, 8].

Compared to the controlled partial pressure in the incubator, the atmospheric partial pressure might decelerate proliferation of C2C12 (Fig. 8(B) & (D)), although that might accelerate differentiation of C2C12 (Fig. 8(A)).

When mechanical stimulation is applied to the scaffold, the whole stimulation cannot always be transmitted to the cells. When the tension applied to a scaffold, the deformation of scaffold generates compression and shear in the different direction simultaneously [14]. The parallelepiped chamber is convenient to observe the response of cells under controlled shear stress [8]. To apply continuous uniform mechanical stimulation to the cells, centrifugal force is used in the present study [6].

Both acceleration of proliferation and orientation of cells are important targets in the research field of regenerative medicine on the cultured biological tissue. The previous study shows that the behavior of cells depends on the electric [1] and magnetic stimulation [12]. Another study shows that mechanical stimulation improves a tissue-engineered human skeletal muscle [2]. The results of the study will contribute to acceleration technique in regenerative medicine

The previous studies show that a mechanical field governs behavior of cells [13-16]. The shear flow governs the orientation of endothelial cells [7, 9]. The shear stress affects the orientation of the smooth muscle cells in the biological tissue [3]. The direction of the mechanical field affects fibroblasts [5]. The effect of shear flow on orientation of cells depends on the kinds of cells [7]. Although HUBEC orients along the stream lines, C2C12 tilts from the stream lines to make myotubes. The previous study shows orientation of cells perpendicular to the stretch direction [4].

Too strong mechanical stimulation damages cells. The moderate mechanical stimulation, on the other hand, might accelerate differentiation of cells [6]. The mechanical stimulation can decrease proliferation of cells [6]. The mechanical stress also exfoliates several cells, which makes vacancy around the adhesive cell. The differentiation might be optimization of cells to the changing environment. The mechanical stress can accelerate differentiation of C2C12 to make myotubes [6].

5. CONCLUSION

The effect of gravitational force on orientation of cell has been studied *in vitro*. To apply excess gravitational force on cells, the cell culture tube was set in a conventional centrifugal machine. The experimental results show that C2C12 extends pseudo, proliferate to the confluent manner and differentiates to myotube even under continuous stimulation of 270 times of the gravitational force.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Effect of Micro Ridges on Orientation of Cultured Cell

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ABSTRACT

The effect of micro ridges on orientation of cultured cells has been studied *in vitro*. Several patterns of micro ridges have been fabricated on a transparent polydimethylsiloxane disk with the photo lithography technique. The ridges consist of several lines of rectangular column: the width of 0.003 mm, the interval of 0.007 mm. Variation has been made on the height of the ridge between 0.0003 mm and 0.0035 mm. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was cultured on the disk with the micro ridges for one week and was observed with an inverted phase contrast microscope. The experimental results show that cells adhere on the top of the ridge and align to the longitudinal direction of the micro ridges with the height between 0.0015 mm and 0.0025 mm.

Keywords: Biomedical Engineering, Cell Culture, C2C12, Lithography, Micro Ridge and Polydimethylsiloxane.

1. INTRODUCTION

Biological cells respond to various environmental factors, such as electric [1], magnetic [2] and mechanical [3, 4] fields. These factors affect cells behaviors: migration, deformation, orientation, proliferation, differentiation and secretion of extracellular matrix. Through these processes, the various environmental factors govern the configuration of the biological tissue.

Cell culture technique has been developed and several methodologies have been clinically applied to regenerative medicine [5]. The acceleration technique for orientation and proliferation of cells has been studied to make a biological tissue *in vitro* or *in vivo* [3, 5]. Control methodology for behavior of cells would be applied to regenerative tissue technology.

The morphology of the surface of the scaffold might affect the orientation of cells and might govern organization of cells [6, 7]. Several methods have been applied to make orientation of cell culture in the previous studies: fibers [8] and grooves [9-11].

In the previous studies, the orientation of cells was controlled by sandwiching the cells between walls: in grooves, or in capillaries. The wall prohibits extension of cells, and regulates the direction of cells. A capillary of sub-millimeter diameter was used to make a cylindrical tissue in the previous study. In such kinds of the wider interval between walls than dimension of the cell of micrometers, direction of each cell might not be controlled.

The cell, on the other hand, might sense the direction of micromorphology. The smaller interval of ridges may control the direction of the single cell [12]. In the present study, the cell has been cultured on the linear ridges.

The photo lithography technique is effective to make micro patterns on the surface of the plate for cell culture. In the present study, the effect of micro ridges on orientation of cultured cells has been studied *in vitro*.

2. METHODS

Micro Ridges

Several (between one and ten) parallel lines of micro ridges have been made on a disk of transparent polydimethylsiloxane (PDMS). The width (W), the interval (I) and the length (L) of the rectangular ridge (Figs. 3, 15) are around 0.003 mm, 0.007 mm, and 2 mm respectively. Variation has been made on the height (H) of the ridge: 0.0003 mm, 0.0007 mm, 0.0015 mm, 0.0025 mm, and 0.0035 mm.

A silicon wafer (Type P, Matsuzaki Seisakusyo, Co., Ltd., Tokyo, Japan) is used for a surface mold for the disk (Fig. 1) in the photo lithography process (Fig. 2). The diameter and the thickness of the wafer are 50 mm and 0.30 mm, respectively.



Fig. 1: Silicon wafer for mold (diameter: 50 mm).


Fig. 2: Photo lithography process.

The surface of the wafer was cleaned by the following process. The surface was exposed to the oxygen gas in a reactive ion etching system (FA-1, Samco Inc., Kyoto) for five minutes: (the oxygen plasma ashing). It was cleaned in an ultrasonic cleaner with 2-propanol for five minutes, with the hydrogen peroxide solution for five minutes, and with the ultrapure water for five minutes. Then, the wafer was dried on the hot plate (AHP-300, Asahi-rika, Chiba, Japan) at 373 K for five minutes.

The photo-resist material of OFPR-800 (Tokyo Ohka Kogyo Co., Ltd, Tokyo, Japan) was coated on the wafer with 0.002 mm thick at 5000 rpm with a spin coater. The photo-resist was baked in an oven (DX401, Yamato Scientific Co., Ltd, Tokyo, Japan) at 383 K for 90 seconds.

The pattern of lines was drawn on the wafer with a laser drawing system (DDB-201K-KH, Neoark Corporation, Hachioji, Japan). To control the dimension of the lines of the mold with the laser drawing system, the parameters were selected as follows: the wave length 408 nm, and the power 20 mW. After the drawing, the photo-resist was baked again in an oven at 393 K for five minutes.

The photo-resist was developed with tetra-methyl-ammonium hydroxide (NMD-3, Tokyo Ohka Kogyo Co., Ltd., Kawasaki, Japan) for 90 seconds. The wafer was rinsed with the distilled water for 30 seconds. To increase the adhesiveness of the coating, the wafer was baked at 393 K for five minutes.

The wafer was etched with the plasma gas using the reactive ion etching system (RIE-10NR, Samuco Inc., Kyoto, Japan) to make lines of the micro groove. The alternative switching mode between C_4F_8 gas and SF_6 gas was applied on the disk.



Fig. 3: Typical location of micro ridges (magnified in bottom) on the plate of PDMS plate.

To exfoliate the residual photo-resist material from the surface, the wafer was exposed to the oxygen gas at power of 50 W with flow of 30 milliliter per minute for five minutes: (the oxygen plasma ashing).

The dimension of the micro grooves of the mold was measured with a laser microscope (VK-X200, Keyence Corporation, Osaka, Japan). Each mold has several groups of ridges dispersed on the disk. The number of lines of ridge varies with each group. Each mold has its own unified height of the ridges.

The surface of the wafer with micro pattern was coated with 0.001 mm thickness of parylene in the parylene coater (PDS-2010, Speciality Coating Systems, Indianapolis, USA).

After the wafer was enclosed with a peripheral wall of polyimide, PDMS (Sylgard 184 Silicone Elastomer Base, Dow Corning Corporation) with the curing agent (Dow Corning Corporation) was poured on the wafer. The volume ratio of the curing agent is ten percent of PDMS. After degassing, PDMS was baked at 383 K for one hour in an oven (DX401, Yamato Scientific Co., Ltd).

The baked disk of PDMS is exfoliated from the mold, and sterilized in an autoclave. The disk with the micro ridges at several positions was cut into the plate of 35 mm diameter (Fig. 3) to be set at the bottom of the dish of six wells. The plate was exposed to the oxygen gas for one minute in a reactive ion etching system (FA-1, Samco Inc., Kyoto) to be characterized as hydrophilic (oxygen plasma ashing), and preserved in the ultrapure water, before the cell culture.

The contact angles were measured between PDMS and medium by the contact angle analyzer (Phoenix-300, Meiwafosis Co., Ltd., Tokyo, Japan), before and after the oxygen plasma ashing.

Cell Culture

The culture dish, which consists of 6 cylindrical wells of 35 mm diameter, was used for cell culture (Fig. 4). The PDMS disk, which has micro ridges on the upper surface, was placed in the bottom of each well, and preserved in medium of D-MEM (Dulbecco's Modified Eagle Medium). C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was used in the experiment. Cells were seeded on the culture plate with the medium of D-MEM at density of 1.5×10^3 cells per cm². Fetal bovine serum (FBS) was added to the medium with the volume rate of 10 percent. Cells were cultured in the incubator for one week.

The deformation of cells near the micro ridges was observed with an inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo) every three hours in 24 hours.

The angle between the longitudinal axis of the cell adjacent to the ridge and the longitudinal direction of the ridge was measured (Fig. 5).

3. RESULTS

Figs. 6 & 7 exemplify the results of the measurement of the micro grooves of the manufactured molds. The data of the depth of the grooves fluctuate in the range of 30 percent of the target dimension.



Fig. 4: Cell culture on disk of PDMS with micro ridges dipped in the dish of six wells.



Fig. 5: Angle between longitudinal axis of cell and longitudinal direction of ridge. Dimension from left to right is 0.5 mm.

Fig. 8 shows the contact between PDMS and the medium. The figure shows that the angle decreases (Fig. 8B) after oxygen plasma ashing on the surface of PDMS. The angle decreases when the surface of PDMS becomes hydrophilic.



Fig. 6: Dimension of groove of mold measured with laser microscope. Lower figure of tracing along vertical direction in upper figure (dimension from left to right is 0.015 mm) shows depth of 0.0007 mm.



Fig. 7: Cyclic gap in tracing of surface of mold with laser microscope shows depth of grooves of 0.0015 mm.



Fig. 8(A): Drop of medium on PDMS before oxygen plasma ashing.



Fig. 8(B): Drop of medium on PDMS after oxygen plasma ashing.



Fig. 9: 24 hours of cultivation on ridges of 0.0003 mm height. Cell spreads over the ridges of 0.0003 mm height.



Fig. 10: 6 hours of cultivation near ridge of 0.0015 mm height. A cell adheres on the top of the single ridge, and extends along the longitudinal direction of the ridge.

Figs. 9-13 exemplify cells near the micro ridges during seven days of cultivation. Dimension from left to right is 0.5 mm in Figs. 9-13. The figure shows following behavior of cells. The cells adhere over the low ridge of 0.0003 mm height (Fig. 9). The cells stay on the top of the ridge lower than 0.0025 mm, and extend pseudopodium along the longitudinal direction of the ridge (Figs. 10 & 11). The cells, on the other hand, fall down into the valley of the interval of 0.007 mm between the ridges higher than 0.003 mm, and extend along the longitudinal direction of the valley (Fig. 12). Near the end of the ridge, some cells extend pseudopodium into the space between ridges (Fig. 13).

The distribution of the angle between the longitudinal axis of cell and the longitudinal direction of ridge with the variation of height of ridges is shown in Fig. 14(A), in which data are plotted in the order of decreasing. Between the ridges with height of 0.0035 mm, cells are dropped in the groove between the ridges (Fig. 12), so that the angle is zero. Most of the angles distribute in the area lower than 45 degree, which shows the tendency of orientation of cell along the longitudinal direction of the ridge. The data are integrated to the mean value (point) and the standard deviation (bar) in Fig. 14(B). When the data are distinguished from those at the height of 0.0035 mm, the most of data at the height of 0.0015 mm and 0.0025 mm are lower than 45 degree.



Fig. 11: 3 hours of cultivation on ridges of 0.0007 mm height. A cell adheres on the top of the ridge, and extends along the longitudinal direction of the ridge.



Fig. 12: 2 days of cultivation near ridges of 0.0035 mm height. Cells fall down into the valley between the ridges, and extend along the longitudinal direction of the valley.



Fig. 13: 3 days of cultivation near ridges of 0.0035 mm height. Cell extends pseudopodium into the valley between ridges. Dimension from left to right is 0.5 mm.

The experimental results show that cells adhere on the top of the ridge and align to the longitudinal direction of the micro ridges with the height between 0.0015 mm and 0.0025 mm.

4. DISCUSSION

In the previous studies, the micro pattern was designed to control the orientation of cell in the tissue *in vitro* [13-16]. The adhesion of cell was controlled with hydrophilic and hydrophobic microdomains of polymer [17]. The tissue was designed to control interaction between cell and polymer *in vitro* [5]. Control methodology for orientation and proliferation of cells has a potential to be applied to a bio-actuator [18].

To make orientation of cells in the cultured tissue, several morphologies were applied to the cell culture in the previous studies: a micro capillary of glass and a groove of sub-millimeter. In these experiments, the cells orient just along the wall, and cells are forced to be aligned to the longitudinal direction of the space sandwiched between walls [12].

The biological cells, on the other hand, might sense micro morphology of the surface smaller than their own dimension through their cytoskeleton or membrane [9, 10]. The effect of the curvature of grooves of micro meter order on the behavior of cell was studied in the previous study [19]. Morphology of nanometer order of the surface might affect behavior of cells [20, 21].



Fig. 14(A): Angle between longitudinal axis of cell and longitudinal direction of ridge at various heights of ridges.



Fig. 14(B): Mean angle (point) between longitudinal axis of cell and longitudinal direction of ridge in relation to height of ridge. The vertical bar shows standard deviation.



Fig. 15(A): Orientation of cell between high ridges (middle) and near ridge (right). *W*, width; *I*, interval; *H*, height.



Fig. 15(B): Orientation of cell on low ridge.

In the most of previous studies, there were two ways to design the micro structure of scaffold for cell culture: nanometer -structure with molecular structure, and sub-millimeter-structure with surface machining. Between these two dimensions, micrometer-structure might be controlled with the photolithography technique. In the present study, the effect of micrometer order of morphology on the orientation of cells has been studied.

The experimental results show that cells move and elongate according to the ridge. Although the single ridge is not enough to make orientation of cells, multiple ridges affect the cells orientation [12]. The surface morphology of micrometer affects cells behavior. The differentiation of cells can be accelerated with micro ridges [12].

The experimental results with C2C12 show that cells adhere on the top of the ridge and align in the longitudinal direction of the micro ridges with the height between 0.0015 mm and 0.0025 mm (Fig. 14). The ridge, which is lower than 0.0003 mm, is not enough to make orientation of the cell. The ridge, which is higher than 0.003 mm, is too high for the cell to stay on the top of the ridge.

Between the higher ridges, the cells fall down into the valley between ridges, and extend along the valley (Fig. 12). Near the higher single ridge, the cells tend to align along to the wall of the ridge.

The alignment of cells affects that of neighbor cells. A cell may rotate to make parallel alignment to the neighbor cell. A cell may also make parallel alignment through proliferation. Through the mechanism, the alignment of the single cell governs orientation of cells in the tissue.

To study on the effect of surface micro morphology of the solid scaffold on the alignment of the cell, the alignment of the longitudinal direction of the cell has been measured within 24 hours after adhesion of the cell. If cells proliferate to the confluent state, interaction between cells is dominant, and each environmental effect on orientation of cells cannot be distinguished each other.

In the differentiation of C2C12, cells fuse and make myotube. The alignment of cells may govern the alignment of myotube.

In the case of solid surface of the scaffold, the micro grooves might give a space for the flow of the medium between the cell and the scaffold. That might make better condition to grow the tissue.

5. CONCLUSION

The effect of micro ridges on orientation of cultured cells has been studied *in vitro*. Several lines of micro ridges have been fabricated on a transparent polydimethylsiloxane disk with photo lithography technique. The experimental results show that myoblasts adhere on the top of the ridge and align to the longitudinal direction of the micro ridges with the height between 0.00015 mm and 0.0025 mm.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Effect of Ultrasonic Vibration on Culture of Myoblast

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ABSTRACT

The effect of mechanical stimulation of vibration on cultured cells has been studied in vitro. To apply the vibration on the cultured cells, a piezoelectric element was attached on the outside surface of the bottom of the culture dish. The piezoelectric element was vibrated by sinusoidal alternating voltage (Vp-p < 16 V) at 1.0 MHz generated by a function generator. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was used in the test. Cells were seeded on the polystyrene bottom of the dish at the density of 1000 cells/cm². After adhesion of cells in 24 hour, cells are exposed to the ultrasonic vibration in two manners: intermittently (for thirty minutes a day) or continuously. The cells were observed with a phase contrast microscope every day during the cell culture. The experimental results show that C2C12 proliferates and differentiates even under continuous vibration.

Keywords: Biomedical Engineering, C2C12, Cell Culture and Vibration.

1. INTRODUCTION

Ultrasonic vibration has been applied to human body in several cases: measurements of deep structure of body, and lithotrity [1, 2].

Cell culture technique has been developed, and cells have been cultured in controlled environment. Effect of vibration on cell culture was studied in previous studies. In most cases, the vibration with low frequency was applied to cell culture: shaking the scaffold, or vibrating the scaffold at audible frequency.

Several methodologies have been clinically applied to regenerative medicine. The acceleration technique for proliferation and differentiation of cells has been studied to make tissue *in vivo* or *in vitro* [3-11]. Control methodology for proliferation and differentiation of cells would be applied to the regenerative tissue technology.

The mechanical stress is one of the interested points in the environment of cells, because they receive mechanical force *in vivo*. The mechanical stress on cells might induce various responses: deformation, migration, proliferation, and differentiation. Several methods have been designed to apply the mechanical stress to cells [4-12].

In the present study, the effect of ultrasonic vibration on culture of myoblast has been studied *in vitro*.

2. METHODS

Experimental System

Mechanical vibration was applied to cultured cells with the following experimental system. A piezoelectric element (1Z28D-SYX, Fuji ceramics Corporation, Tokyo), which has 28 mm diameter and 1 MHz resonance frequency, is used for vibrator (Fig. 1). A polystyrene dish of 60 mm of internal diameter (IWAKI 3010-060-MYP) was used for cell culture. A polydimethylsiloxane (PDMS) disk, which contains a piezoelectric element, is attached on the outside surface of the bottom of the dish (Fig. 2).



Fig. 1: PDMS disk contains piezoelectric element. Waves on the drop of water reveal vibration.

The contact between the disk and the dish is kept by affinity between them without adhesiveness. To keep acoustic contact between the outside surface of the bottom of the dish and the piezoelectric element, water is filled between them.

The piezoelectric element was vibrated by sinusoidal alternating current at 1.0 MHz generated by a function generator (PM8572A, Tabor Electronics Ltd.) (Fig. 3). Variation was made on the amplitude (peak to peak) of the sinusoidal voltage (Vp-p): between 3V and 16 V (Fig. 4).

The surface of the medium was observed macroscopically, while the ultrasonic vibration is applied during cell culture.

Cell Culture

C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was used in the test. In the case of intermittent vibration test, sixth passage of C2C12 was used. In the case of continuous vibration test, fifth passage of C2C12 was used. Cells were seeded on the polystyrene bottom of the dish at the density of 1000 cells/cm². Cells are cultured at 310 K with 5 % of CO₂ in an incubator. After adhesion of cells in 24 hour, cells are exposed to the ultrasonic vibration in two manners: intermittently (for thirty minutes a day) or continuously.

C2C12 was cultured with the D-MEM (Dulbecco's Modified Eagle's Medium) containing 10% FBS (fetal bovine serum, after decomplementation). The medium containing penicillin and streptomycin was refreshed every two days.

The culture dish with the piezoelectric element was kept in the incubator to maintain both the temperature of 310 K and the carbon dioxide partial pressure of 5 percent (Fig. 5). Sinusoidal voltage is transmitted to the piezoelectric element from the function generator placed outside of the incubator (Fig. 6).

The cells were observed with a phase contrast microscope (IX71, Olympus, Tokyo) every day during the cell culture for 5 days. On the outer surface of the bottom of the dish, a line of 0.2 mm width or a circle of 1 mm diameter is marked to trace the same area for the cell culture. When the number of cells is counted with Burker-Turk hemocytometer, cells are exfoliated with trypsin, and stained with trypan blue (GIBCO) to eliminate dead cells.

The electric pulses were applied to the cells through the medium at the end of the culture to confirm differentiation of C2C12 to myotubes.



Fig. 2: Piezoelectric element attached on the bottom of the dish.



Fig. 3: Electric circuit: oscilloscope (left), piezoelectric element (middle), function generator (right).



Fig. 4: Voltage tracings of 1 MHz with function generator.



Fig. 5: Cell culture dish with piezoelectric element in incubator.

(A)



Fig. 6: Sinusoidal voltage is transmitted to the piezoelectric element from function generator placed outside of the incubator.

3. RESULTS

The observation of the surface of the medium shows no macroscopic vibration during cell culture in the present experiment (Fig. 7B). Two lines of lights are reflected on the surface in Fig. 7. The surface of the medium shows several slightly convex parts, while the ultrasonic vibration is applied during cell culture with the condition in the present study. At the intensity of the vibration, the electric current is estimated to 0.1 A. The value is calculated from the voltage between the ends of the resistance (Vp-p = 12 V), when the resistance of 51 S⁻¹ is connected in series of the piezoelectric element.

To select the density of seeding, C2C12 was cultured without vibration (Figs. 8 & 9). Fig. 8 shows that C2C12 proliferates to confluent state in three days, when C2C12 seeded in the density of 5000 cells/cm². Fig. 9 shows, on the other hand, that C2C12 proliferates to sub-confluent state in three days, when C2C12 seeded in the density of 1000 cells/cm². For the density of seeding, 1000 cells/cm² is selected in the following cell culture.

The experimental results show no significant effect of continuous vibration at 10 kHz for four days on proliferation of C2C12 (Figs. 10-12). The frequency of 10 kHz makes audible sound, which confirms continuous vibration at the piezoelectric element. Some cells of C2C12 show morphological change after vibration: extended pseudopodia, flake of pseudopodia, decrease of cytoplasm, and exfoliation of cells (Fig. 13).

Figs. 14-17 exemplify C2C12 cultured under intermittent vibration at 1 MHz for 30 minutes a day compared with control study. Fig. 18 shows the number of cells in relation to amplitude of the sinusoidal voltage of vibration at 1 MHz. In every cases, the number of cells increases more than 10 times in 5 days. The number of cells is standardized with that of control in Fig. 18. The proliferation of C2C12 tends to accelerate with the ultrasonic vibration of Vp-p lower than 13 V.



Fig. 7: Surface of medium before vibration (A) and during vibration at 6 V (B), 10 V (C), 16 V (D).



Fig. 8: C2C12 after 3 days after seeding of 5000 cells/cm^2 without vibration. Dimension from left to right is 2 mm.

Figs. 19-21 show C2C12 culture under continuous vibration compared with control study. Even under continuous vibration, C2C12 differentiate to myotubes, which shows repetitive contraction with stimulation of electric pulses.



Fig. 9: C2C12 after 3 days after seeding of 1000 cells/cm^2 without vibration. Dimension from left to right is 2 mm.



Fig. 10: C2C12 after 1 days after seeding of 1000 cells/cm^2 without vibration. Dimension from left to right is 2 mm.



Fig. 11: C2C12 after 3 days after seeding of 1000 cells/cm² without vibration. Dimension from left to right is 2 mm.

4. DISCUSSION

When C2C12 is seeded with the density of 5000 cells/cm^2 , cells proliferate to confluent density in 3 days, which is too short to observe the effect of vibration to proliferation of cells. That is the reason why the density of 1000 cells/cm^2 is selected in the present experiment.



Fig. 12: C2C12 after 5 days after seeding of 1000 cells/cm² without vibration. Dimension from left to right is 2 mm.



Fig. 13: C2C12 after vibration of 16 V for 30 min.



Fig. 14: C2C12 before vibration.

When the voltage, which is applied to the probe, increases, the surface of the medium becomes convex and vibrates (Vp-p > 16 V). The prominent vibration might generate macroscopic flow, which has stirring effect. In the present sturdy, variation has been made on Vp-p in the range smaller than 16 V, although micro vibration might have local stirring effect.



Fig. 15: C2C12 after vibration of 3 V for 30 min.



Fig. 16: C2C12 after 4 days without vibration.



Fig. 17: C2C12 after 24 hours after three days' vibration of 3 V for 30 minutes a day.

Vibration makes agitation in the liquid. Vibration at low frequency makes flow in the liquid. Vibration with high energy destroys structure. The surface of the medium does not vibrate macroscopically during cell culture in the present experiment. The surface of the medium shows slight convex, while the ultrasonic vibration is applied during cell culture with the condition in the present study (Fig. 7).



Fig. 18: Relation between number of cells and Vp-p after 5 days of culture. Datum at 0 V shows datum without vibration.



Fig. 19: C2C12 cultured for 48 hours under continuous vibration. Diameter of the circle is 1 mm. Circle marked on the outside of the bottom has 1 mm diameter to trace the same area of culture.



Fig. 20: C2C12 cultured for 11 days without vibration. Dimension from left to right is 2 mm.

Both acceleration of proliferation and orientation of cells are important targets in the research field of regenerative medicine on the cultured biological tissue. The previous study shows that electrical stimulation enhances differentiation of muscle cells [3]. Another study shows that mechanical stimulation improves a tissue-engineered human skeletal muscle [4].



Fig. 21: C2C12 cultured for 11 days under continuous vibration. Dimension from left to right is 2 mm.

The previous studies show that a mechanical field, on the other hand, governs behavior of cells. The shear flow governs the orientation of endothelial cells [9, 11]. The shear stress affects the orientation of the smooth muscle cells in the biological tissue [5]. The direction of the mechanical field affects fibroblasts [7].

Too strong mechanical stimulation damages cells. The moderate mechanical stimulation, on the other hand, might accelerate differentiation of cells [8]. The mechanical stimulation can decrease proliferation of cells [8]. The mechanical stress also exfoliates several cells, which makes vacancy around the adhesive cell. The differentiation might be optimization of cells to the changing environment. The mechanical stress can accelerate differentiation of C2C12 to make myotubes (Fig. 17).

The effect of low-frequency ultrasound on neuronal activity was studied in the previous study [1]. Low-intensity ultrasound treatment might increase mass transport, and enhance C2C12 cell proliferation, metabolic activity, and differentiation of cells [2]. The wave length of ultrasound at frequency of 1 MHz through water is 1 mm, when the velocity of ultrasound through water is 1 km/s. The wave length is near the dimension of aggregation of cell of 0.01 mm.

5. CONCLUSION

Effect of ultrasonic vibration on culture of myoblast has been studied *in vitro*. To apply the vibration on the cultured cells, a piezoelectric element was attached on the outside surface of the bottom of the culture dish. The experimental results show that C2C12 proliferates and differentiates even under continuous vibration.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic

Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Culture of Myoblast on Gold Film Sputtered on Polydimethylsiloxane Disk

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ABSTRACT

A transparent thin gold film has been designed to culture myoblasts on the surface. The thin gold film was formed on the surface of the polydimethylsiloxane disk by vacuum deposition. The thickness of the film is 30 nm estimated with the current during sputtering. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) was cultured for one week on the film. The proliferation of cells was observed with an inverted phase contrast microscope every day. The experimental results show that the proliferation of the cell on the gold film is able to be observed through the transparent gold thin film with the microscope. The water contact angle shows hydrophilic surface of the gold film, which accelerate adhesion and proliferation of cells.

Keywords: Biomedical Engineering, C2C12, Film Electrode, Gold, Sputtering and Polydimethylsiloxane.

1. INTRODUCTION

Cell culture technique has been developed and several methodologies might clinically be applied to regenerative medicine [1]. C2C12 (mouse myoblast cell line originated with cross-striated muscle of C3H mouse) adheres to the scaffold, proliferates and differentiates to myotubes *in vitro* [2]. These behaviors of the cell depend on the micro property of the surface.

The photolithography technique enables design of microstructure of the solid surface for the scaffold of cell culture. The contact angle is one of the parameters for the physical property of the surface. When the water contact angle in the air is smaller than 1.6 rad on a surface, the surface is hydrophilic. The biological cell adheres to the hydrophilic surface. The oxygen plasma ashing is one of the procedures to make the surface hydrophilic. Polydimethylsiloxane (PDMS) is used frequently in the photolithography process. The surface of PDMS is hydrophobic. The surface of the metal, on the other hand, is hydrophilic.

The effect of the surface of the scaffold on cell culture has been studied in the previous studies [3-6]. Several micro-fabrication processes have been designed to control adhesion of biological cells *in vitro* [4-6].

In the present study, gold has been sputtered to make a transparent thin film of gold on polydimethylsiloxane disk, and the behavior of myoblast on the surface has been observed microscopically.

2. METHODS

Film Electrode

A transparent thin gold film has been designed to culture myoblasts on the film. The thin gold film is formed on the surface of the polydimethylsiloxane (PDMS) disk

A silicon wafer (Type N, Matsuzaki Seisakusyo, Co., Ltd.,

Tokyo, Japan) is used for a surface mold for the disk. The diameter and the thickness of the wafer are 50 mm and 0.30 mm, respectively. The surface of the wafer was coated with 0.001 mm thickness of Parylene (Specialty Coating Systems, Inc., IN, USA). After the wafer is enclosed with a peripheral wall of polyimide, PDMS (Dow Corning Corporation, MI, USA) is poured with the curing agent on the wafer. After being degased, PDMS is baked at 383 K for one hour in an oven. The diameter of PDMS disks is 51 mm. The thicknesses of the two kinds of PDMS disks are 2 mm and 5 mm.

To trace the area of the film, a mask of aluminum disk (52 mm diameter, 0.2 mm thickness) has been manufactured (Fig. 1). The mask has a pair of void of 15 mm square at the counter ends for gold deposition. Both surfaces of the disk of PDMS and of the mask of aluminum were cleaned in the etching system (FA-1, Samco Inc., Kyoto), before the sputtering process.

The thin gold film was formed on the surface of the PDMS disk of 2 mm thickness by vacuum deposition in the sputtering equipment (SC-70AT, Sanyu-Electron Co., Ltd., Tokyo, Japan) (Fig. 2). The thickness of the deposited film on the PDMS disk is controlled with the electric current of the equipment: 30 nm with 300 mA in the present study.

Another PDMS disk of 5 mm thickness, which has a hole of 32 mm diameter, is attached on the PDMS disk with electrode to make a rim along the circle (Figs. 3&4). Two PDMS disks are fixed each other with PDMS as adhesive by the following process. The liquid of PDMS was painted on the surface of the two disks. Two disks were attached together, degassed, and baked at 383 K.

After sterilized in the autoclave, the assembled disks are exposed to the oxygen gas in a reactive ion etching system (FA-1, Samco Inc., Kyoto) to be characterized as hydrophilic (oxygen plasma ashing). The disks are placed in polystyrene dish of 70 mm diameter, and used as the culture dish (Fig. 5).

Contact Angle

For comparison, gold was deposited on the half of the surface of PDMS disk (Fig. 6). Variation was made on the process of electric current at spattering: 300 mA, 200 mA followed by 100 mA, and 100 mA followed by 200 mA. Water contact angles were measured by the contact angle analyzer (Phoenix-300, Meiwafosis Co., Ltd., Tokyo, Japan).

The surface of the disks was exposed to the oxygen gas in a reactive ion etching system (FA-1, Samco Inc., Kyoto) to be characterized as hydrophilic (oxygen plasma ashing). The contact angles after five minutes from exposure were compared with that before exposure.

Cell Culture

C2C12 (Mouse myoblast cell line originated with cross-striated muscle of C3H mouse) of thirteenth passage was used for the cell culture. D-MEM (Dulbecco's Modified Eagle Medium) containing 10% FBS (Fetal Bovine Serum) and 1% penicillin/ streptomycin was used for the medium. The cells were seeded on the dish of PDMS with the density of 1000 cells/cm³. Cells were cultured in the incubator at 310 K with 5% CO₂ for one week. The medium were refreshed every two days. Cells were observed with the inverted phase-contrast microscope (IX71, Olympus Co., Ltd., Tokyo) every day.



Fig. 1: Mask of aluminum for deposition.



Fig. 2: Deposited gold film on the surface of PDMS.







Fig. 4: Culture dish of PDMS.



Fig. 5: Culture dish of PDMS placed in polystyrene dish of 70 mm diameter.



Fig. 7: Contact angle (1.7 rad) on the surface of PDMS before oxygen plasma ashing.



Fig. 6: Gold was deposited on the half of the surface of PDMS disk (upper half in the figure) by three kinds of sputtering process. 300 mA (left), 200 mA followed by 100 mA (middle), and 100 mA followed by 200 mA (right).

3. RESULTS

The color of 100 mA followed by 200 mA is darker than that of 300 mA (Fig. 6), which shows that the thickness of the deposited gold film might increase by sputtering two times. Figs. 7-11 show the water contact angle on the surface of PDMS and gold in the air. Fig. 7 shows the water contact angle bigger than 1.6 rad, which reveals that the surface of PDMS is hydrophobic. Fig. 8 shows the angle smaller than 1.6 rad, which reveals that the surface of the gold film is hydrophilic.

The water contact angle decreases after sputtering, so that the oxygen plasma ashing was effective for the surface to be hydrophilic (Figs. 9&10).

Fig. 11 shows smaller angle than Fig. 8, which shows the process of the spattering two times is better to make the hydrophilic surface.



Fig. 8: Contact angle (1.1 rad) on the surface of gold sputtered (300mA) area on PDMS before oxygen plasma ashing.



Fig. 9: Contact angle (0.45 rad) on the surface of PDMS after oxygen plasma ashing.



Fig. 10: Contact angle (0.38 rad) on the surface of gold sputtered area on PDMS after oxygen plasma ashing.



Fig. 11: Contact angle (0.80 rad) on the surface of gold sputtered (100mA & 200 mA) area on PDMS before oxygen plasma ashing.



Fig. 12: C2C12 on PDMS after 24 hours. Dimension from left to right is 1 mm.



Fig. 13: C2C12 on gold film after 24 hours. Dimension from left to right is 1 mm.

The cells are easily observed with the microscope through the transparent thin film of gold on the PDMS surface (Figs. 13, 15, 16). The Cells adhere, extend pseudo, and proliferate both on PDMS and on gold film (Figs. 12-15). Proliferation of C2C12 tends to be faster on the gold film than on the PDMS even after oxygen plasma ashing.



Fig. 14: C2C12 on PDMS after 6 days. Dimension from left to right is 1 mm.



Fig. 15: C2C12 on gold after 6 days. Dimension from left to right is 1 mm.



Fig. 16: More cells adhere in the gold film area (right half) on the surface of PDMS. Dimension from left to right is 1 mm.

4. DISCUSSION

The behavior of a biological cell depends on several factors: electrical [7], magnetic [8], and mechanical factors [9-12]. The gold film has a potential to be used as an electrode to control the electrical factors.

The electrical resistance (R) between the ends of the film is calculated by Eq. 1.

$$R = k L / (d b) \tag{1}$$

In Eq. 1, k is resistivity [S⁻¹ m], L is length [m], d is thickness [m], and b is width [m].

The resistivity of gold is 2.21×10^{-8} m/S at 293.15 K. The electrical resistance (*R*) between the ends of the film is estimated 2 S⁻¹, when $k = 2.21 \times 10^{-8}$ m/S, L = 15 mm, d = 0.00001 mm, and b = 15 mm.

To avoid cells get into the space between the PDMS disk and the culture dish, the rim was formed around the PDMS disk, and the suspension of the cells was poured on the PDMS disk.

The contact angle on the gold film deposited on PDMS depends on the process of deposition.

Several factors might govern the adhesiveness of the cell: the micromorphology of the deposited gold film, and the chemical characteristics of the surface. The contact angle is one of the parameters for the physical property of the surface. Proliferation of cells also might depend on these factors.

The photolithography technique has been applied to fabricate the micro channel [13]. The microfluidic system has been applied to sort biological cells [14, 15], and to trap biological cells [16, 17]. The system also used to study local environment around the cultured cell [3, 6]. The micro pattern of the surface has been applied to study the surface effect of adhesion of cells [4, 5, 18-20].

The micro-fabrication technique has also been applied to design microfluidic systems *in vitro* [21-24]. The technique will also be applied to handle cells in diagnostics *in vitro*. The difference of the affinity between the scaffold and the cell might control adhesion of cells *in vitro*. The methodology was developed to estimate adhesiveness of myoblast [25]. The microstructure was designed to capture biological cells [26].

5. CONCLUSION

A transparent thin gold film on the surface of the polydimethylsiloxane disk has been designed to culture myoblasts on the surface. The experimental results show that the proliferation of the cell on the gold film is able to be observed through the transparent gold thin film with the microscope. Proliferation of myoblast tends to be faster on the gold film than on the PDMS even after oxygen plasma ashing.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese

Ministry of Education, Culture, Sports and Technology.

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Effect of Flow Stimulation on Cultured Osteoblast

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ABSTRACT

An effect of flow stimulation on cultured osteoblast has been studied *in vitro*. To apply the continuous shear flow on cultured cells, a cell culture dish with a donut shaped canal was contained on a shaker. Variation was made on the flow rate with the rotational speed of the shaking plate. MC3T3-E1 (osteoblastic cell line) was incubated for a week under the flow stimulation. To observe the migration of cells, the cells in the targeted area were exfoliated with a tip of a micropipette when the cells proliferated to sub confluent density. Proliferation and migration of the cells were observed with a phase contrast microscope during the cell culture. The experiments show the following results: the osteoblasts proliferate even under the continuous shear flow, and the osteoblasts migrate even to the counter direction along the flow, although osteoblasts do not show special orientation under the flow condition.

Keywords: Biomedical Engineering, Cell Culture, Osteoblast, Proliferation, Migration and Flow.

1. INTRODUCTION

Cell culture technique has been developed and several methodologies have been clinically applied to regenerative medicine. The acceleration technique for orientation and proliferation of cells has been studied to make tissue *in vivo* or *in vitro* [1-9]. Control methodology for orientation and proliferation of cells would be applied to the regenerative tissue technology.

The mechanical stress is one of the interested points in the environment of cells, because they receive mechanical force *in vivo*. The mechanical stress on cells might induce various responses: deformation, migration, proliferation, and differentiation. Several methods have been designed to apply the mechanical stress to cells [2-10].

A transmission point of the stress to a specimen is important. In many studies, the stress is applied to a scaffold [2-5]. When fixation between the cell and the scaffold is not enough, the stress is not transmitted to the cell. A flow, on the other hand, can be used to apply a stress field to a specimen [7-10]. The specimen directly receives the shear stress in the shear flow.

High shear flow might deform cell, peel cells off the scaffold, inhibit proliferation as well as tissue formation. Mild shear flow, on the other hand, might accelerate migration, proliferation, and secretion of materials, which make the extra cellular matrix.

The amount of the bone tissue is controlled with osteoclasts and osteoblasts: osteoblasts form bone, although osteoclasts re-absorb bone. The amount of the bone decreases in the microgravity field.

In the present study, the effect of flow stimulation on cultured osteoblast has been studied *in vitro*.

2. METHODS

Donut-Shaped Open Channel

A donut-shaped open channel system for the cell culture has been designed to apply a shear flow on cells *in vitro* (Fig. 1). A polystyrene culture dish of 50 mm internal diameter (IWAKI 3010-060-MYP) was used. A transparent polydimethylsiloxane (PDMS) disk (30 mm diameter, 3 mm thick) is attached on the inner bottom of the culture dish to restrict the space for the flow of the medium. The PDMS disk is attached at the center of the polystylene culture dish with affinity between their surfaces without adhesive.

A disk of polymethylmethacrylate has been made to adjust the center of the culture dish and to trace the same position in the serial cultivation in the dish (Fig. 2). The disk has a pinhole at the center, and lines in the radial direction. The lines are marked in the middle position of the donut channel for the microscopic observation. The intervals of the lines are 1 mm and 0.3 mm (Fig. 6). The diameter of the disk is 50 mm. A circle of 30 mm diameter is marked on the disk. The circle is used for adjusting the position of the PDMS disk on the bottom of the culture dish, when the PDMS disk is attached on the bottom of the culture dish. Every position in the culture dish is adjusted with the circumferential wall attached on the rim of the disk.



Fig. 1: PDMS disk attached on the inner bottom of the culture dish at the center with the adjuster plate.



Fig. 2: Adjuster plate of 50 mm diameter has a hole at the center and lines in the radial direction.

The culture dish is placed on a plate, which inclines at 0.1 rad of the horizontal plane (Fig. 3). The plate rotates to generate a swing motion (WAVE-PR, Taitec, Co., Ltd., Koshigaya). Variation was made on the rotating constant speed of the plate: 5, 30, and 40 revolutions per minute (rpm) (0.52, 3.1, 4.2 rad/s). The inclination of the rotating plate was changed to 0.05 rad at 5 rpm. The motion produces a one-way counter clockwise steady vortex flow in the medium through the donut-shaped open channel. The flow speed v (m/s) in the middle part of the donut channel is proportional to the rotating speed N (rad/s).

$$v = r N \tag{1}$$

In Eq. 1, r is radius of the middle part of the channel: 0.04 m. he calculated speeds are 1 cm/s, 6 cm/s, and 8 cm/s, respectively.

The continuously swinging plate is placed in an incubator (Fig. 4), where both the temperature of 310 K and the carbon dioxide partial pressure of 5 percent are maintained.

Cell Culture

MC3T3 (an osteoblast precursor cell line derived from Mus musculus (mouse) calvaria) -E1 was used in the test.



Fig. 3: Culture dish placed on shaker: counter clockwise flow.



Fig. 4: Culture dish on shaker in the incubator.



Fig. 5: Protocol of cell culture.

MC3T3-E1 was cultured with the alpha-MEM (alpha modified Eagle's minimal essential medium) containing 10% FBS (fetal bovine serum), which was added after decomplementation. The medium also ontains 2.4% of sodium bicarbonate aqueous solution (NaHCO₃, 75 g/L) and 1% of Antibiotic-Antimycotic (penicillin, streptomycin and amphotericin B, Life Technologies). The medium was refreshed every three days during cell culture.

The cells were seeded on the donut canal (Fig. 1) in the density of 1000 cells/cm² with 3 cm³ of medium.

Microscopic Study

Cells were observed with an inverted phase-contrast microscope (IX71, Olympus, Tokyo).

After the cells were cultured for 24 hours without flow in the incubator, the cells were cultured under the continuous flow for several days on the shaker in the incubator. The number of cells was counted in the randomly selected square area of 1 mm^2 in the channel at 72 hours of cultivation.

After the cells were cultured for 144 hours, the cells in the strip area of 0.8 mm width perpendicular to the direction of the flow were exfoliated with a tip of a micropipette, and the migration of cells to the strip area was observed every hour for 12 hours.

The top of the extended area of cells migration is evaluated as the perpendicular distance from the line of exfoliation. The slope of the collinear approximation of the increase of the distance is evaluated as the speed of migration. The speed is evaluated at upper and lower streams of the exfoliated area.

The results with flow stimulation were compared with that of without flow stimulation. Every cell is cultured in the donut channel in the present experiment.

3. RESULTS

Cells were observed by microscope after cultivation for 24 hours (Fig. 6). The figure shows that MC3T3-E1 adheres to the bottom of the dish in 24 hours.

The flow synchronized with the rotational movement of the tilted plate was observed by floating tracers.

Figs. 7-9 exemplify the cells after 72 hours of cultivation under flow compared with that without flow. The figures show that MC3T3-E1 proliferates to sub confluent density in 144 hours even under the continuous shear flow.

Figs. 10-12 show the density of cells after 120 hours of cultivation with flow (F) in comparison with that without flow (C). Each point in the vertical line shows the datum of randomly selected square area of 1 mm^2 in the same culture dish. The experimental data show the following results. Proliferation is inhibited with flow higher than 6 cm/s (Fig. 10), although proliferation tends to increase with the flow of 1 cm/s.

Figs. 13 & 14 exemplify cells after 72 hours cultivation. The figures show that the longitudinal axes of the cell distribute in random direction.

Migration of cells to the exfoliated area is exemplified in Fig. 15. The figure shows that cells migrate even to the counter direction along the flow. The speed of migration of cells is calculated from the slope of the tracings of migration with the collinear approximation (Fig. 16). Fig. 17 shows the speed of migration in each flow condition: flow of 1 cm/s (1C-1CL), 6 cm/s (6C-6L), 8 cm/s (8C-8L), without flow (C), upper side of the flow (U), lower side of the flow (L), without flow before exfoliation (CU, CL). The speed of migration of counter direction along the flow decreases with the flow higher than 6 cm/s.



Fig. 6: Immediately after cell seeding (upper), and after 24 hours of cultivation (lower). Dimension from left to right is 2 mm.



Fig. 7: Cells after 144 hours of cultivation without flow (upper), and with flow of 1 cm/s (lower). The arrow shows direction of flow. Dimension from left to right is 2 mm.



Fig. 8: Cells after 144 hours of cultivation without flow (upper), and with flow of 6 cm/s (lower). The arrow shows direction of flow. Dimension from left to right is 2 mm.



Fig. 9: Cells after 144 hours of cultivation without flow (upper), and with flow of 6 cm/s (lower). The arrow shows direction of flow. Dimension from left to right is 8 mm.



Fig. 10: Density of cells after 72 hours of cultivation with flow of 1 cm/s (F1-F3), and without flow (C1-C6).





Fig. 11: Density of cells after 72 hours of cultivation with flow of 6 cm/s (F1-F3), and without flow (C1-C3).



Fig. 12: Density of cells after 72 hours of cultivation with flow of 8 cm/s (F1-F3), and without flow (C1-C6).



Fig. 13: Cells after 72 hours of cultivation without flow. Dimension from left to right is 2 mm.



Fig. 14: Cells after 72 hours of cultivation with flow. Direction of flow is downward. Dimension from left to right is 2 mm.



Fig. 15: Immediate after exfoliation (left); after 12 hours cultivation without flow (upper right) with flow (from top to bottom) of 6 cm/s (lower right). Dimension from left to right is 2 mm, respectively.



Fig. 16: Migration of cells vs. time with flow of 6 cm/s.

Migration speed, mm / hour



Fig. 17: Migration speed of cells in 12 hours.

4. DISCUSSION

The murine-derived MC3T3-E1 cell line provided by the American Type Culture Collection (ATCC) is a well-known osteogenic cell culture model system to test materials *in vitro*. The osteoblastic cell line MC3T3-E1 has been established from a C57BL/6 mouse calvaria and selected on the basis of high alkaline phosphatase (ALP) activity in the resting state. Cells have the capacity to differentiate into osteoblasts and osteocytes *in vitro*.

It is not easy to estimate the shear stress value on the wall in the present experiment, because the medium has the free surface. The parallel piped chamber is convenient to observe the response of cells under controlled shear stress [8]. The shear stress on the bottom of the donut canal of the dish in the present study is estimated as several pascal with the behavior of endothelial cells in the same experimental flow system [7, 8].

When mechanical stimulation is applied to the scaffold, the whole stimulation cannot always be transmitted to the cells. To apply mechanical stimulation to the cells, centrifugal force [6] or shear flow is used alternatively in the present study.

Both acceleration of proliferation and orientation of cells are important targets in the research field of regenerative medicine on the cultured biological tissue. The behavior of biological cells depends on electric and magnetic fields [1, 11]. Another study shows that mechanical stimulation improves a tissue-engineered human skeletal muscle [2].

The previous studies show that a mechanical field, on the other hand, governs behavior of cells [12]. The shear flow governs the orientation of endothelial cells [7, 9]. The shear stress affects the orientation of the smooth muscle cells in the biological tissue [3]. The direction of the mechanical field affects fibroblasts [5].

Too strong mechanical stimulation damages cells. The moderate mechanical stimulation, on the other hand, might accelerate differentiation of cells [6]. The mechanical stimulation can decrease proliferation of cells [6]. The mechanical stress also exfoliates several cells, which makes vacancy around the adhesive cell [13-16]. The differentiation might be optimization of cells to the changing environment.

The effect of shear flow on orientation of cells depends on the kinds of cells [7]. Although HUBEC orients along the stream lines, C2C12 tilts from the stream lines to make myotubes. The previous study shows orientation of cells perpendicular to the stretch direction [4].

5. CONCLUSION

The effect of flow on behavior of osteoblasts has been studied *in vitro*. To apply continuous shear flow on cells, the cell culture dish with the donut shaped canal was contained on the shaker. The experimental results show that the osteoblasts migrate even to the counter direction along the flow, and that the osteoblasts proliferate even under the continuous shear flow without orientation to the flow direction.

6. ACKNOWLEDGMENT

This work was supported by a Grant-in-Aid for Strategic Research Foundation at Private Universities from the Japanese Ministry of Education, Culture, Sports and Technology.

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Simulation of Ridge Formation in Cortical Bone near the Anterior Cruciate Ligament Insertion: Bone Remodeling due to Interstitial Fluid Flow

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ABSTRACT

The ridge formation in the cortical bone near the anterior cruciate ligament (ACL) insertion has been simulated based on bone remodeling due to interstitial fluid flow. Three-dimensional (3-D) data of cortical bone at the distal end of the femur were obtained from a computer topography image of a human knee joint, and were transformed to a 3-D voxel model consisting of voxel elements of 500 \times 500 \times 500 μ m in size. A finite element analysis software (ABAOUS) was utilized to determine the interstitial fluid flow in the cortical bone in response to the application of ACL tensile force, tibial compressive force, and patellar compressive force. Bone remodeling analysis was repeated until equilibrium in which a new voxel element was added on a surface where local flow rate was higher than predefined thresholds. Results revealed that ridge formation occurred in response to the force application and the ridge structure was dependent on the thresholds of interstitial fluid flow rate.

Keywords: Biomedical Engineering, Finite Element Analysis, Bone Remodeling, Resident's Ridge Formation Anterior Cruciate Ligament and Interstitial fluid flow.

1. INTRODUCTION

Resident's ridge near the anterior cruciate ligament (ACL) on the femoral condyle in the knee joint is clinically used as a landmark to find the bone tunnel position at the surgical ACL reconstruction surgery. Numerous number of anatomical researches have been reported as regard with the dimension and structure of the ridge [2] [3] [4] [5] [6]. However, the analytical model of femur used in the studies were two dimension, so it was difficult to simulate to physiological condition. Therefore, we developed a three

dimension femoral cortical bone model to perform a precise bone remodeling analysis in the present study. To biomechanical explain the Resident's ridge formation, we hypothesized that due to interstitial fluid flow in response to external loads. The analysis was reported with a variety of the threshold of flow rate. However, the mechanism of formation of the ridge has not been well explained. A 3-D model of the distal femur has been created with the cortical bone in the present study. Meanwhile, the structure of trabecular bone has been biomechanically based on bone remodeling due to compressive strass/strain [7] and interstitial fluid flow [8] [9]. Therefore, Fujie et al proposed that the Resident's ridge formation can be explained by bone remodeling due to compressive strain [10] and interstitial fluid flow [11].

2. METHODS

Finite Elements Model

The cancellous bone of femur, the tibia and patella were removed from the CT image of the human knee joint with the image editing software of GIMP (GNU Image Manipulation Program) (Fig. 1). Finite element model was configured with voxel elements using VOXELCON (QUINT, 2013). The side of voxel was 500 μ m. ABAQUS (6.13) was used for finite element analysis in which each element was assumed to be homogeneous and isotropic with elastic modulus of 20 GPa [10] and Poisson's ratio of 0.3. The permeability of the element was 5.13×10^9 m² [12] for the interstitial fluid of 0.001 Pas of viscosity. The pore pressure elements (C3D8RP) were used to visualize the interstitial fluid flow.

(a)



Fig. 1: Three dimensional model of cortical bone at the distal end of femur and forces applied to femur three external.

Calculation

The force applied from the patella to the femur (F_3) was calculated with the following equations,

$$F_{1} = F_{2} \cos\theta_{1} + F_{3} \sin\theta_{2}$$
(1)

$$F_{2} \sin\theta_{1} = F_{3} \cos\theta_{2}$$
(2)

where, F_1 is quadriceps force while, F_2 is the force of patellar ligament force, θ_1 is acute angle between F_1 and F_2 , and θ_2 is the complementary angle between F_1 and F_3 .

In the present simulation, F1 was set at 136 N, referred from quadriceps using muscles analysis of quadriceps during gate using Opensim. The direction of F_1 was parallel with the bone axis of the femur. θ_1 is 0.43 rad that corresponds to the angle between the bone axis and the patellar ligament. θ_2 was 0.17 rad that corresponds to the flexion angle of the knee joint at the heel strike position in gate.

The point of application of F_3 was referred from the previous anatomical study by Tecklenburg et al. [13]. The position of attachment of the ACL was determined with the previous anatomical study by Andrew et al. [16] and Iriuchishima et al. [17]. The proximal end of femur was fixed while, the force of 300 N was applied on head medical and lateral of the distal end of the femur (Fig. 1).

 F_1 was increased to 600 N while F_3 was also increased to the target value for 1s. Subsequently, F_2 was increased to the target value, while F_1 and F_3 were kept constant (Fig.4).

Bone Remodeling Process

The bone remodeling process was started, when F_2 reached to the target value. A new voxel element was added on the element, in which the flow rate exceeds the threshold value of either 0.75, 1.00, 1.25 or 1.50 µm/s, under an assumption that bone formation occurred where local flow rate exceeded the threshold. This calculation process was repeated twice. Note that ACL attachments were elevated to the surface of a remodeled bone voxel (Fig.2).



Fig. 2: Upward movement of the ACL insertion to adding elements where the flow rate exceeds thresholds value.

3. RESULTS

Fig. 3 shows the distribution of the flow rate before remodeling calculation started. The direction of interstitial flow rate was almost perpendicular to the surface of the cortical bone (Fig. 4). The high flow rate occurred in the anterior distal area of attachment of the ligament. Figs. 5-8 show the first and second steps of remodeling with the threshold of the flow rate of 0.75 μ m/s, 1.00 μ m/s, 1.25 μ m/s and 1.50 μ m/s, respectively.

The area of bone formation decreased as the increase of the threshold of flow rate. Resident's ridge-like bone formation occurred at the thresholds of the flow rate of 0.75 μ m/s and of 1.00 μ m/s (Figs. 9(A) and 9(B)). On the other hand, such formation did not occurred at the threshold of the flow rate of 1.25 μ m/s.





Fig. 3: Distribution of flow rate before the start of remodeling calculation.



Fig. 4(A): Interstitial fluid flow before the start remodeling calculation at cortical bone surface.



Fig. 4(B): Flow rate distribution at the first step of remodeling calculation



Fig. 5(A): Interstitial fluid flow-induced bone remodeling at the first step of remodeling calculation with a threshold of flow rate of 0.75 μ m/s.



Fig. 5(B): Interstitial fluid flow-induced bone remodeling at the second step of remodeling calculation with a threshold of flow rate of 0.75 μ m/s.



Fig. 6(A): Interstitial fluid flow-induced bone remodeling at the first step of remodeling calculation with a threshold of flow rate of $1.00 \mu m/s$.



Fig. 6(B): Interstitial fluid flow-induced bone remodeling at the second step of remodeling calculation with a threshold of flow rate of 1.00 μ m/s.



Fig. 7(A): Interstitial fluid flow-induced bone at the first step of remodeling calculation with a threshold of flow rate of $1.25 \,\mu$ m/s.



Fig. 7(B): Interstitial fluid flow-induced bone remodeling at the second step of remodeling calculation with a threshold of flow rate of 1.25 μ m/s.



Fig. 8(A): Interstitial fluid flow-induced bone remodeling at the first step of remodeling calculation with a threshold of flow rate of $1.50 \mu m/s$.



Fig. 8(B): Interstitial fluid flow-induced bone remodeling at the second step of remodeling calculation with a threshold of flow rate of $1.50 \mu m/s$.



Fig. 9(A): Remodeled bone with a threshold of flow rate of 0.75 μ m/s.



Fig. 9(B): Bone remodeling with a threshold of flow rate of 1.25 μ m/s.



Fig. 9(C): Bone remodeling with a threshold of flow rate of 1.50 μ m/s.



Fig. 9(D): Bone remodeling with a threshold of flow rate of 1.50 μ m/s.

4. DISCUSSION

In the present study, the cortical bone remodeling analysis was performed around the ACL insertion site of the femur based on a hypothesis that bone remodeling was caused by interstitial fluid flow. The interstitial fluid flow rate was analyzed in response to three external forces to femur, tibial compressive force, patella compressive force and ACL tensile force. For the analysis, the magnitude and direction of the forces and mechanical properties of the femur were referred from previous literatures. As a result, we succeeded to complete the 3-D analysis as regard with the interstitial fluid rate in the distal femur.

Results revealed that Resident's ridge-liked bone formation occurred at the threshold of relatively low flow rates (0.75 μ m/s and 1.00 μ m/s) while it did not occur at the threshold of relatively high flow rate (1.25 μ m/s and 1.50 μ m/s). Weinbaum et al. indicated that osteoblast is stimulated for bone formation when the fluid flow-induced shear stress to the cell exceeds 1 Pa [19]. Although detailed analysis has not been performed, flow-induced shear stress may be adequate for bone remodeling at the flow rate between 0.75 μ m/s and 1.00 μ m/s.

It is well known that many ridges can be observed near ligament and tendon insertions, such as the tibial tuberosity near tibial insertion of the patella tendon. Further studies possibly explain the mechanism of the formation of three ridges.

5. CONCLUSION

We developed a detailed 3-D model of the distal femur and performed a bone remodeling analysis due to interstitial fluid flow for the explanation of the formation of the Resident's ridge. It was suggested that the Resident's ridge-like bone formation occur at relatively low thresholds of flow rate.

6. ACKNOWLEDGMENT

The present study was supported in part by the Grant-In-Aid for scientific Research B (#25282134) from the MEXT, Japan, the Priority Research Found from Tokyo Metropolitan University, and the MEXT-Supported Program for the Strategic Research Foundation at Private Universities, 2008-2012 (BERC, Kogakuin University) and 2013-2017 (FMS, Kogakuin University).

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Radiotherapy Conformal Wedge Computational Simulations and Nonlinear Optimization Algorithms

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ABSTRACT

Radiotherapy wedges constitute an important group within the generic classification of so-called Beam Modification Devices (BMD). Wedges are subdivided into Static, Dynamic, and Omni Wedges sug-groups. The standard static wedge attenuates the beam progressively, in such a way that the dose delivery is higher at the thin side, and lower at the broader side. The slope of the inferior surface has the geometry of the hypotenuse of a triangle, formed by the lateral wall of the wedge. This contribution presents a new conformal wedge filter design whose sloping surface is divided in non-continuous steps for better dose delivery distribution in the tumor. We develop the basic mathematical algorithm, by using the classical AAA algorithm. The mathematical analysis is carried out over the integral attenuation factor that modulates the convolution factor of the dose delivery. The geometrical design of the conformal wedge is showed in several sketches, and Numerical Simulations with appropriate software are presented. Results agree to the presented mathematical formulation in simulations of the attenuation exponential for a 2steps conformal wedge. Finally, and introduction of formulation for Beam-divergence Limit angle is shown, with an initial analysis for the specific conformal wedge.

Keywords: Dose, Attenuation Exponential Factor (AEF) (AEF), Simulations, Nonlinear Optimization.

1.-INTRODUCTION

Wedge filters (WF) constitute a common medical device used in Therapy, Inverse/Forward Treatment Radiation Planning Optimization (TPO), to conform tumor shape during radiation delivery. They belong to the generic group of Beam Modification Devices (BMD) [3,4]. The WF function is to attenuate the radiation beam in increasing magnitude, usually along the transversal direction to the photon-beam. As a result, the dose delivery magnitude forms a curved distribution in that transversal direction for each radiation-depth value within the photon dose-deposition region. Classical wedges geometry have a straight sloping face corresponding to the hypothenuse of the triangle defined by the lateral sides. The clinical problem in TPO is, in occasions, to optimize the dose using WF, but the shape of the WF not always conforms the necessary geometrical conditions for the optimal tumor radiation. In this paper we present a Mathematical-Computational Model/Design for a Conformal Wedge Filter¹, (CWF) that has a sloping geometry divided into several non-continuous steps. The dose distribution in these types of wedges changes its shape for a more conformal radiation distribution, if the tumor presents irregular geometry/contour, rather non-spherical.Since the manufacturing/engineering design for these devices is the simple/understandable, paper we focus on the mathematical/geometrical/modeling formulation to carry out the design with engineering precision, obtain an optimal radiation dose, and implement the algorithm into the planning system software. We developed a mathematical formula to avoid nonsymmetrical/irregular beam attenuation created by the alloy steps, that is, to sort the so-called double-attenuation. Additionally, we show computational simulations/graphics of the Attenuation

Exponential Factor (AEF,Equation(8)) to be compared with classical wedge filters. The aim of this Technical Paper is, primarily, on the mathematical formulation that could be used to design/manufacture a conformal wedge model. The second part is related to simulations of the AEF distribution to prove, in theory, that a conformal wedge gets more precise dose distribution when the tumor contour is not spherical, which is the frequent clinical case.

2.-THE AAA ALGORITHM. MATHEMATICAL FORMULATION

The Analytic Anisotropic Algorithm, AAA, is a well-known and extensively used Superposition-Convolution Model in RT. AAA is is evolved from an initial Integral Superposition Convolution Model, whose parameters were optimized using large Monte Carlo experimental data in water. The starting Physical Equation to develop the model [31-34] was a Yukawa Kernel based on the formulation structure of the classical Yukawa Gaussian Potential for Electromagnetism, as follows,

$$D_p(r,z) = I(z) \frac{c}{\sigma^2(z)} e^{-\frac{r^2}{\sigma^2(z)}};$$

Equation (1)

where $D_{r}(r,z)$ the absorbed dose, normalized to one photon, r is the radial coordinate

$$r = \sqrt{x^2 + y^2}$$

Eq (2)

in the transverse plane at depth z. The characteristic function I(z)denotes the area integral of the dose over the transverse plane of the pencil beam at depth z, normalized to one photon, and

 σ^2 ;

is the mean square radial displacement of the profile at depth z. Next, a mathematical development based also in experimental data and Fourier Transform, was carried out [31-34], to transform the initial formula on a triple sum of Gaussians (Superposition) from the initial simple Gaussian, and optimize the coefficients according to photon beam experimental data. As a result, the Pencil Model Dose at a depth z and into an almost differential cylinder (Triple Gaussian Pencil Beam) whose diameter is 2r is,

$$D_p(r,z) = \sum_{k=1}^{k=3} I(z) \frac{c_k}{\sigma_k^2(z)} e^{-\frac{r^2}{\sigma_k^2(z)}};$$

Eq (4)

The constants here are normalized in such a way that

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$$\sum_{k=1}^{k=3} c_k = 1;$$

Eq (3)

Eq (5)

all the parameters are tabulated [31-34]. The derivation of the coefficient ck with the help of the Fourier transform, have already been described in the papers [31-32]. Tabulations of I(z), ok(z), and ck , based on Monte Carlo calculations of photon pencil beams for Co-60 gamma radiation and bremsstrahlung from 6 to 18 MV, have already been published [31-32]. This triple-Gaussian representation of the pencil beam has been chosen because its convolution with the photon flux distribution $\Phi(x,y,z)$ at depth z can be analytically performed in many practical cases. An important contribution to the saving of computer time and storage space is thereby achieved, because numerical convolutions or applications of look-up tables from their fitting formulas are partially avoided. The analytical form of the resulting dose distributions may also offer other, yet unknown, applications. The triple-Gaussian pencil beam approach can be applied to radiation beam profiles that represent rectangular satellite blocks and wedge filters, as it is the case of this paper. The derivation of the coefficients ck with the help of the Fourier transform, have already been described in the papers [32-34]. The term 'Superposition' comes from the sum of three Gaussians into the integral. The term 'Convolution' comes from the mathematical transformation carried out into the Dose-Deposition Kernel at the Integral. With this Triple Gaussian D_p (r,z), a Kernel K (x,y,u,v) was constructed to implement the dose term into the integral expression for the initial Superposition-Convolution Model in water, and then, the integral dose results in general as follows,

$$D(x,y,z) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} I(z)\Phi(x,y,z) k(x,y,z) ds;$$

Eq (6)

where I(z) is the area integral of the absorbed dose over a plane perpendicular to the pencil beam axis at depth z per incident photon [33], Φ is the photon fluence distribution of the beam per unit of intensity, and K is the kernel expression corresponding to the PBM, which is called the PB dose kernel, and describes the spatial distribution of the absorbed energy. This kernel could perfectly include any other PBM, for example the classic Anesjö model [1] or others. Now we focus on the aim of this research. The complete Triple Gaussian Pencil beam Model for one IMRT beamlet in water [Ref 2], when using wedges of angle α and taking into account the Collimator Divergence Angle (usually very small), θ then reads [8],

$$D(x'_{1},x'_{2},z') = I(\alpha,z') \int_{-2a}^{2a} \int_{-2b}^{2b} \Phi_{z'}(\alpha,\theta,u'_{1},u'_{2},z') \times \\ \times \sum_{k=1}^{3} \frac{c_{k}}{\pi \sigma_{k}^{2}(z')} e^{-((x'_{1}-u'_{1})^{2}+(x'_{2}-u'_{2})^{2})/\sigma_{k}^{2}(z')} du'_{1} du'_{2};$$

Eq (7) [erratum, limits of integral -a',a',-b',b']

where x_1' , y_1' , z', u_1' , u_2' , are the bixel dose coordinates [Ref (2)] This is the formulation of the AAA algorithm in water. For inhomogeneous tissues, larger formulation that is not used in this contribution is applied. The AAA algorithm has evolutioned significantly from the initial model in water. A number of correction factors have been introduced to implement it into the Planning System (usually Eclipse, Varian). The determinations of algorithms for inhomogeneous tissue formulation correspond to next publications. We step towards the mathematical model construction for the specific conformal wedge.

3.-METHODS/MODEL ALGORITHM/SIMULATIONS

The geometrical design of 1-step and 2-step conformal wedges is not complicated because it corresponds to basic irregular polyhedral design. In addition, we used trigonometrical calculations to determine the δ angle to avoid double attenuation effect in 3-steps conformal wedges.

The dose integral formula, when using wedges (Eqs [8,9]), has an additional AEF (Eq [8]) that gives the attenuation caused by the wedge alloy. This exponential modulates the kernel of the dose

(the triple Gaussian in this AAA algorithm). In this way, to avoid hot spots at the borders of the tumor is better got with a conformal wedge; because it is possible to use a broader part at the tumor border (more attenuation compared to standard wedges, less dose), joint to a thinner part for the main volume of the tumor (less attenuation compared to standard wedges). It is intended to explain sharply this point by using the Superposition Principle for Radiation Dose in Figure (3). We used the classical AAA Radiotherapy Dose Distribution for Pencil Beam Model (water), socalled Anisothropic Analytic Algorithm, as previously [1,2,4]. Simulations are made taking the AEF that multiplies the convolution integrand part that corresponds to the generic AAA Dose-Delivery Integral Equation (8) [4]. Therefore, it is possible to extrapolate/hypothesize the theoretical results for the comparison of the dose distribution at a depth z in the x direction (internalexternal, anatomically speaking), from the center of tumor towards the peripherical region (Fig 6). The center is less attenuated by the AEF, and the border is more attenuated by the AEF, and this, mathematically, will occur also with the dose distribution (Superposition Principle). The AEF in 2D (we denote 2D, according to [2]) formula, which modifies Photon-Fluence Distribution, reads [7],

$$\begin{split} \Phi_{w}(u,v,z) &= \Phi_{u}(u,v,z) \times \\ &\times e^{\left[-\mu_{w}\times\left(L\pm\frac{cu}{F+z}\right)\times\left(\frac{\sin\alpha}{\cos(\alpha+\varphi)}\right)\right]} = \Phi_{u}(u,v,z)\times f(u,z,\alpha,\varphi); \\ &\text{with} \quad f(u,z,\alpha,\varphi) = e^{\left[-\mu_{w}\times\left(L\pm\frac{cu}{F+z}\right)\times\left(\frac{\sin\alpha}{\cos(\alpha+\varphi)}\right)\right]}; \end{split}$$

Eq (8)

where **u**,**v** are beam output size coordinates,**z** depth,**L** half wedge length,**c** output collimator-wedge surface distance,**F** total filter length,**a** wedge angle,**φ** beam/beamlet divergence angle.The constant **µ**_w is tabulated [4],for different LINAC Photon-Energies.This Photon-Fluence,for wedges use,is implemented into the AAA Dose delivery Fundamental Formula as follows,

$$D(x, y, z) = I(z) \int_{-a}^{a'} \int_{-b}^{b'} \Phi_{w}(u, v, z) \times \\ \times \sum_{k=1}^{k=3} \frac{c_{k}}{\pi \sigma_{k}^{2}(z)} \times e^{\left[-\left[(x-u)^{2} + (y-v)^{2} \right] / \sigma_{k}^{2}(z) \right]} du dv;$$

Eq (9)

where I(z) is Beam Intensity, c_k and σ_k are constants tabulated through optimization [4], and u,v, are output collimator coordinates. According to all this, the Mathematical Model Algorithm is,

$$\overrightarrow{F}(u, z, \alpha, \varphi) = \begin{pmatrix} f_1(u_1, z, \alpha_1, \varphi_1) \\ \cdots \\ f_k(u_k, z, \alpha_k, \varphi_k) \end{pmatrix};$$
with every $u_k, \alpha_k, \varphi_k \in [L_k, L_{k+1}];$ and $2L = \sum_{k=1}^K L_k$

and K is the number of wedge steps;

Eq (10)

The functions $f_{\rm K}$ correspond to the defined function f in [Eq (1)]. And we have divided the wedge surface in [1,K] intervals corresponding to every step, the total length of the wedge is 2L. With this formulation, it is mathematically possible to set a Nonlinear Multi-Objective Function to optimize the given parameters of the Conformal Wedge in Eq (10), using Eqs (8,9). This formulation will be developed/presented in subsequent publications. In consequence, a series of AEF values related to u

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coordinate distribution programs and graphics have been done. Simulation data is:field size $30x30cm^2$,18MEV LINAC Photon-Energy,depth z=8cm [Fig 2].

4.-RESULTS/COMPUTATIONAL SOFTWARE

In Figures1.1 and 1.2 we show a basic geometrical design of a conformal wedge. Fig1.1 presents a 1-step 2D conformal wedge, which does not have any double-attenuation design problem. Figure1.2 details a 2-step 2D conformal wedge geometric design, that shows how the double-attenuation could become a dose engineering-precision difficulty. Double attenuation occurs when any divergent beamlet can collide with the notch of the step-discontinuity after emerging from the wedge-interior. This phenomenon cause an additional attenuation of the beamlet, and if the threshold between two consecutive steps is high, the double attenuation can be a source of error. According to Mathematical Formulation which is presented in Eqs1,2 (Trigonometry calculations),Double-attenuation angle $\boldsymbol{\delta}$ Fig (5) is,

$$\delta = \operatorname{arctg}\left(\frac{L-m}{S+c}\right);$$

Eq (11)

where L is the half lateral length (standard) of the wedge,and factor **m** is defined by trigonometry with the distance from the step corner notch to the lateral wedge side, **S** is the distance to the wedge surface from step notch corner, and **c** [Ref 7] is the distance from collimator output to wedge surface.

Simulations of lateral 2D AEF magnitude distribution for 45° wedge are presented in Fig 2 related to u coordinate. In that pic,it is proven the adaptation of the AEF on the tumor contour threshold. The simulation was done with a standard wedge of 45° (standard size, [2]) modified to a conformal one, right broad part. The decrease of the AEF curves while wedge thickness increase, causes a dose-reduction towards the tumor edge since AEF multiplies the integrand triple-Gaussian principal convolution term. We explain Figs 2,3 in other words. The wedge-exponential factor (AEF) of the graph, multiplies within the integral the doseconvolution factor. The integral can be considered as a summatory of these multiplications. Therefore, if there is a threshold in the magnitude of the exponential (AEF), it is also projected by multiplication to the total dose. Software for simulations was carried out with specific Freemat 4.2 (Samit Basu GNU General Public License) subroutines. The matrices for the curves construction had to be modified/transposed sometimes to carry out mathematical operations. Basically, we have to design the simulation program setting vectors for each step interval with the corresponding values of u coordinate and ϕ angles. After that, we use 2D graphics subroutines to implement the AEF formula with these vectors. Some special arrangements have to be carried out to join the curves together in one graph.

5.-BEAM LIMIT DIVERGENCE ANGLE (LA).CONCEPT AND FORMULATION

In previous contributions [3,4], the LA was mathematically defined and developed for wedges. We detail here the main formulas and one sketch of LA, together with a picture of the so-called conformal wedge. Given a fixed collimator output to wedge surface distance, LA is defined as the maximum angle of divergence that can be reached by the whole radiation beam without emerging at any point of lateral walls of the wedge. Photon-Beam divergence angles values vary around 20 degrees. The Beam minimum divergence depends on the collimator design quality, and in general of the precision engineering manufacturing of the LINACs. LA is useful because of several reasons. Avoids hot spots, sub-optimal dose delivery, planning system software propagation errors, overdose at OARS, and repetition of planning work caused by sub-optimal dose delivery calculations. The LA for a conformal wedge calculation presents some additional difficulties. However, the primary approximation is to take as LA for a CWF he value of the deepest step of the wedge. Main

formulation for LA in standard wedges is for the principal pencil beam [Ref 9],

$$\theta_{L}[Geometrical] = arctg\left(\frac{[r]_{u_{2=0}}}{P}\right);$$
with
$$u_{1}^{2} + u_{2}^{2} = r^{2};$$

Eqs (12)

where

 $r = b - tan\theta \times tan\alpha \times (b + a) = r(\theta);$ from [Ref 9], and

$$\mathbf{r} = \mathbf{b} - \tan\theta \times [\tan\alpha \times [\sqrt{b^2 - u_2^2} + a]] = \mathbf{r}(\theta);$$

Eqs (13)

where P is the distance between the collimator output and wedge surface (perpendicular, [Ref 9]), r is the vector defined by coordinates u_1 and u_2 (wedge surface as in Figs (1.1, 1.2), alpha is the wedge angle, and theta is the beamlet divergence angle. These limiting geodesics are sketched in red in Fig (2.1). We have used the constraint for inferior geodesic [Ref 9] and Figs (1.1, 1.2),

$$u_1^2 + u_2^2 = b^2$$
;

Eq (14)

Therefore, to make sure the components of the decomposed beam Fig (4) have a correct output point the following conditions should hold

$$\theta_1 \leq \operatorname{arctg}\left(\frac{a}{P+2c}\right); \quad \theta_2 \leq \operatorname{arctg}\left(\frac{a}{P+c}\right);$$
Eqs (15)

where a is the half-side of transverse maximum length of wedge, and c is collimator-wedge surface distance. Angle decomposition is sketched in Fig 4.

6.-DISCUSSION AND CONCLUSIONS

The principal result in Fig 2 shows a sharp threshold in the magnitude of the AEF that is convoluted into the integral to determine the dose delivery. The Physical/Mathematical significance of this threshold (calculated about 6 magnitude order in simulations) proves that the conformal wedge is useful, at least theoretically, to obtain a better conformal Dose over the tumor irregular-contour, compared to the conventional standard wedge filter. However, since the available radiotherapy planning time is always reduced, conformal wedges manufacturing should be made in a few options range at first, both for optimization software implementing in Planning System and LINAC fast mechanical setting before radiation.

9.-ACKNOWLEDGEMENTS

This article was accepted by Mother's Day in May 2014. It is dedicated to my mother and my father with love and gratitude. They have given me the life and my education. Therefore, the principal merit of this research belongs to them.

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Figures 1.1,1.2 - Upper, basic geometrical design of Conformal Wedge Filter (1 and 2 notchs) and Angle-Step Geometry. Lower, 1-step Conformal wedge showing the principal beam (one pencil-beam) and a divergent pencil-beam.



(2)

(1)



Figures 2 and 2.1-Upper, Simulation for Standard 45° Wedge. In the graphics the shape of the wedge is inserted in order to check the attenuation threshold created by the wedge step. Lower, the main concept of Limit angle that yields to trigonometric calculations presented in previous publications.





 $Dose = \int (Wedgel - Factor(AEF)) \times (Dose - Factor) ds +$

+ [(Wedge2 - Factor(AEF)) × (Dose - Factor)ds;

Figure 4.-An sketch of the decomposed beam for LA calculations.



Figure 5.-An sketch of the double-attenuation geometry calculations, related to Eq (11). L is in Eq (11) the half-length of the total transversal length of the wedge.



Figure 6.-A simple sketch of the dose distribution of a conformal wedge for a lung tumor (Google Images).



Figure 7.-A simulation graphics to show the enhanced threshold of the AEF. Basically, we have to design the simulation program setting vectors for each step interval with the corresponding values of u coordinate and ϕ angles. After that, we use 2D graphics subroutines to implement the AEF formula with these vectors. Some special arrangements have to be carried out to join the curves together in one graph.

Influence of the Training Methods in the Diagnosis of Multiple Sclerosis Using Radial Basis Functions Artificial Neural Networks

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ABSTRACT

The data available in the average clinical study of a disease is very often small. This is one of the main obstacles in the application of neural networks to the classification of biological signals used for diagnosing diseases. A rule of thumb states that the number of parameters (weights) that can be used for training a neural network should be around 15% of the available data, to avoid overlearning. This condition puts a limit on the dimension of the input space.

Different authors have used different approaches to solve this problem, like eliminating redundancy in the data, preprocessing the data to find centers for the radial basis functions, or extracting a small number of features that were used as inputs. It is clear that the classification would be better the more features we could feed into the network.

The approach utilized in this paper is incrementing the number of training elements with randomly expanding training sets. This way the number of original signals does not constraint the dimension of the input set in the radial basis network. Then we train the network using the method that minimizes the error function using the gradient descent algorithm and the method that uses the particle swarm optimization technique.

A comparison between the two methods showed that for the same number of iterations on both methods, the particle swarm optimization was faster, it was learning to recognize only the sick people. On the other hand, the gradient method was not as good in general better at identifying those people.

Keywords: Neural Networks, Radial Basis Functions, Particle Swarm Optimization, Signal Processing, Wavelets, Health Sciences, Multiple Sciencesis.

1. INTRODUCTION

Doctors utilize BSAEP to diagnose patients with multiple sclerosis. MS can reveal, among other symptoms, a decrease of the wave V amplitude, an increase on absolute latencies and interpeak interval latencies I-III, I-V, III-V. But the border between pathological and normal values

sometimes is not well defined [1]. Doctors very often find it difficult to state the rules they use to reach their conclusions, and their success rate is higher for healthy people than for sick people. It should be noted that the biological signals studied in this paper are Brain Stem Auditory Evoked Potentials (BSAEP) for the diagnosis of Multiple Sclerosis, the techniques that we applied to them could be easily applied to study any time series related to the evolution of biological parameters. For instance, they could easily be used dealing with VEP, ECG's, EEG or EMG's potentials, [2] - [8].

The relevant features in a BSAEP would involve the relative position of peaks and not their absolute value. Figure 1 shows the BSAEP of one of the healthy people, who is called healthy # 25, one of the sick people, called sick # 3., and another one of a patient called sick #6.



Green: Healthy # 25, Black: Sick # 3, Red: Sick # 6

Fig.1. Different BSAEP signals

The BSAEP of a sick people and a healthy one could look sometimes very similar, see Figures 2 and 3. But other times the shape of the signal is completely different for sick people, as Figure 3 and 4 shows.


Figure 2: Healthy # 40



Figure 3: Sick patient #13



Figure 4: Sick patient # 50

We work with an artificial neural network, that uses radial basis functions, but is trained using two different methods. One method tries to minimize the error function using the gradient descent algorithm with decreasing learning rates, by locating where the gradient is equal to zero [9]. The other method uses the particle swarm optimization technique [10], [11], [12].

But before we feed the signals to the neural networks, we preprocessed and compress them. The preprocessing begins by using the same time interval for all signals [13]. Then we normalize them [14]. Since we need to identify the instants in time at which certain events occur, we use wavelet transforms for the compression [15]. We assume that they will be able to capture the amplitude and relative position of the peaks of the signals, information that doctors use for their diagnosis.

For this compression we use all the 37 different wavelet transforms found in MATLAB that allow us to capture the decrease of the wave V amplitude, and an increase of interpeak interval latencies.

Once they have been compressed, the author selected a small number of the most significative features, according to the Kolmogorov-Smirnov statistical criteria, following the ideas found in a previous paper [16]. These selected coefficients were then used as inputs. It is quite clear that the classification would be better the more features we could feed into the network.

We have a set of 193 BAEP signals, obtained from the Hospital Ramon y Cajal, Madrid (Spain), where 70 are normal signals, i.e., corresponding to healthy people, and 123 belong to patients diagnosed with multiple sclerosis. Small samples impose a limit on the number of parameters that can be learned by neural networks. In this paper we first increment the number of training elements, using randomly expanded training sets [17] and we use them to train the radial function network, following the ideas on [18], [19].

Clustering algorithms were used previously to find centers and radii for the radial basis functions [20], [21]. The availability to generate an arbitrary number of samples removes not only the need to find centers and radii, but also the constraint that the number of original signals places on the dimension of the input set of the network. For each neuron we can determine the coordinates of the center (the same number as the inputs), the radius and the output weight. Thus, an n input network, with m radial functions, would require the fitting of $m^*(n + 2)$ parameters. This implies that the computing time will be in the order of m*n, but it will also depend upon the number of iterations performed in the training. So we still must select, from the hundreds of wavelet coefficients, only a handful of them and they must be the coefficients that contain the most significant features [22]. We use these networks with different kinds of wavelets and the Kolmogorov-Smirnov test as the criteria for the selection of 25 input coefficients. Our hidden nodes consists of 4 radial basis functions.

Once the radial basis function has been trained with each method, we tested them and recorded our results. The process was repeated seventeen times, and we obtained the mean and standard deviation of all the cases. As a result, we could see that for the same number of iterations on both methods, the particle swarm optimization was faster, but tended to recognize mostly the sick people On the other hand, the gradient method was in general better at recognizing the healthy people.

2. PRE-PROCESSING OF DATA

Expert doctors use the shape of the principal components of the Brain Stem Auditory Evoked Potential (BSAEP) signal to determine if a person is sick or healthy. This suggests that the wavelet transform of the BSAEP could be used to capture the features that determine if a person is sick or healthy with the help of a neural network.

We have a set of 193 BSAEP signals. The signals were taken from 84 people with multiple sclerosis, using the left and/or right hemisphere and from 35 healthy volunteers, using both hemispheres. The signals for the sick people, where obtained from the Hospital Ramon y Cajal, Madrid (Spain). These signals where acquired from people that complied with the criteria needed to establish a diagnosis of clinically definite multiple sclerosis (MS): A reliable history of at least two episodes of neurologic deficit, and objective clinical signs of lesion at more than one site within the Central Nervous System. Since the disease affects the way signals are transmitted in the brain, a recording of the reaction of the brain to external stimuli should reflect the existence of the disease. Thus doctors can diagnose the disease using BSAEP.

When doctors diagnose this disease they often find it difficult to state the rules they use to reach their conclusions. We aim to help them with the diagnosis using an artificial neural network with radial basis functions in the hidden nodes

In order to work with the signals, we digitized them using a scanner, and restricted them to a common time (the minimum of all of them). Then we generated analog signals using cubic splines. Finally we selected 512 equidistant points, from the analog signals. After this process was done, we applied all the discrete wavelet transforms found in MATLAB to the set of 512 points already obtained. Since we need to identify the instants in time at which certain events occur, we use wavelet transforms because we assume that they will be able to capture the amplitude and relative position of the peaks of the signals, information that doctors use for their diagnosis.

It is impossible to feed the coefficients supplied by the wavelet transforms directly into a neural network. It is clear that the more features we could feed into the neural network, the better the classification would be.

Therefore we increment the number of training elements, using randomly expanded training sets [17]. We generate 579 new signals, with the same proportion of sick and healthy people as in the original set, i.e. 369 for sick people and 210 for the healthy ones. In fact for For each of the two clusters corresponding to sick and healthy people, an estimation of the values for the elements in the probability density function, $f_{kME}(z)$, also denoted as $N_k(\mathbf{U}, \mathbf{R})$, k =1,2 Eq.(1), that maximized the differential entropy for that cluster, were computed.

$$\mathbf{N}_{\mathbf{k}}(\mathbf{U},\mathbf{R}) = \frac{1}{(\sqrt{2\pi})^{n+1} |R_{\mathbf{k}}|^{\frac{1}{2}}} e^{-\frac{1}{2}(z-U_{\mathbf{k}})^{T}R_{\mathbf{k}}-1(z-U_{\mathbf{k}})}$$
(1)

Here z denotes an input-output data vector, U_k is the mean vector of the cluster k, R_k is the covariance matrix of the same cluster, $|R_k|$ is its determinant, and T denotes the operation that performs the vector transpose operation. We represent the estimation of the mean vector as \hat{U}_k and of the covariance matrix as \hat{R}_k , where a diagonal load was added to insure its invertibility

With this information, data were drawn for each cluster using the formula given in Eq. (2)

$$Z^{i} = \hat{U}_{k} + \hat{L}_{k} S^{i} \tag{2}$$

where s^i is an independently identically distributed (i.i.d.) vector sequence drawn from N(0,1), and \hat{L}_k is the Cholesky lower triangular matrix from the decomposition of \hat{R}_k .

Then from the hundreds of wavelet coefficients, we select 25 coefficients using the Kolmogorov-Smirnov test.

3. NEURAL NETWORK ARCHITECTURE

The radial basis function network architecture used for this work can be seen in Fig. 5. There are n input nodes in the fanout layer, m nodes and a bias in the hidden layer, and one output node.



Figure 5: Radial basis function neural network

The value of n is 25, as the number of most significant coefficients selected. As for m we used 4, so the total number of free parameters is 105, well within the range of the 15% to 20% of the number of training elements.

The network was trained using the 37 different wavelet bases offered in MATLAB: all biorthogonal bases (bior11- bior68), all Coiflets bases (coif1-coif5), the first 10 Daubechies bases (db1-db10) and the 7 first Symlets bases (sym2- sym8).

The input-output space of our data requires that all the values of every coefficient on our sample, are normalized, with mean zero, and standard deviation of one. This avoids the problem that the output values, being far greater than any of n inputs in the case of sick people, could dominate the making of the partitions and in doing so, defeat the purpose of the algorithm. The mean value for each coefficient, and the corresponding standard deviation should be kept, to be utilized for the normalization of any future input vector that needs to be tested.

For the method of minimizing the error function using the gradient descent algorithm, each training process consisted of 10,000 random presentations, beginning with different random values. In this case the learning rates $\eta(k)$ for the centers, the radii and the weights were given by the linear function

$$\eta(k) = \eta_0 + (\eta_1 - \eta_0) * \frac{k}{NPR}$$
(3)

where *k* is the iteration step, NPR is the number of presentations, η_0 is the initial learning rate, set at 0.001, and η_1 is the final rate, set at 0.08. These values for the initial and final learning rate for both the hidden and input layers were known to be acceptable.

Wavelet	Average	St. Deviation
bior11	56%	0.01
bior13	29%	0.07
bior15	59%	0.16
bior22	85%	0.03
bior24	51%	0.10
bior26	95%	0.00
bior28	13%	0.03
bior31	1%	0.00
bior33	55%	0.13
bior35	23%	0.06
bio37	63%	0.10
bior39	61%	0.01
bior44	93%	0.00
bior55	19%	0.02
bior68	34%	0.11
coif1	27%	0.07
coif2	32%	0.08
coif3	35%	0.09
coif4	20%	0.05
coif5	95%	0.23
db1	12%	0.03
db2	49%	0.12
db3	80%	0.04
db4	65%	0.16
db5	6%	0.01
db6	31%	0.07
db7	35%	0.03
db8	93%	0.23
db9	33%	0.08
db10	92%	0.22
sym2	8%	0.02
sym3	60%	0.03
sym4	25%	0.06
sym5	20%	0.05
sym6	55%	0.07
sym7	72%	0.02
sym8	69%	0.17

Wavelet	Average	St. Deviation
bior11	100%	0.00
bior13	100%	0.00
bior15	70%	0.26
bior22	99%	0.00
bior24	99%	0.00
bior26	98%	0.01
bior28	53%	0.29
bior31	100%	0.00
bior33	100%	0.00
bior35	100%	0.00
bio37	100%	0.01
bior39	99%	0.00
bior44	100%	0.00
bior55	100%	0.00
bior68	100%	0.00
coif1	100%	0.00
coif2	100%	0.00
coif3	100%	0.00
coif4	100%	0.00
coif5	91%	0.06
db1	100%	0.00
db2	78%	0.42
db3	98%	0.01
db4	99%	0.01
db5	100%	0.00
db6	100%	0.00
db7	100%	0.00
db8	100%	0.00
db9	100%	0.00
db10	100%	0.00
sym2	19%	0.25
sym3	100%	0.00
sym4	100%	0.00
sym5	100%	0.00
sym6	100%	0.00
sym7	100%	0.00
sym8	98%	0.01

 Table 2: Particle Swarm Optimization

For the method of minimizing the error using the particle swarm optimization we used 10 particles, and each of them updates its position and its velocity 1000 times.

Once the artificial neural networks were trained, we checked the results with our original set of data, and recorded the general rate of success and the corresponding rates for sick and healthy people. We repeated the process 17 times for each method and for each wavelet.

4. EMPIRICAL RESULTS

After all the training had occurred, we took the average and standard deviation of all the samples. Tables 1 and 2 shows the results for diagnosis for sick people using the gradient algorithm and the particle swarm optimization algorithms for training, respectively. Both tables have the same structure. Each row corresponds to the success rates for a particular wavelet basis whose name appears in the first column. The second column reflects the general success rate for recognizing the sick people and the third column of the table shows the standard deviation corresponding to the sample of trainings.

Looking at table 1, it is worth noting that in the case of the particle swarm optimization, although the average is very high in 33 of the wavelet decomposition, the values of the standard deviation are very high for the other 4 cases, with values of 0.25 (sym2), 0.26 (Biorthogonal 15), 02.9 (Biorthogonal 28) and 0.42 (Daubechies 2). On the other hand, in table 2, there are only 4 cases with very high average, and all of them, except one, have the highest values of the standard deviation, although not as high as in table 1. In fact, these standard deviations are 0.22 (Daubechies 10), 0.23 (Coiflet 5) and 0.23 (Daubechies 10).

It is worth noting that two wavelet that performed poorly according to the results in table, 2, (Biorthogonal 28 and Symlet 2) also performed poorly,, with averages of 13% and 8%, as shown in table 1

There are other samples that were computed, but due to the lack of space they are not shown. In the conclusion some of their properties will be discussed.

5. CONCLUSIONS

Radial basis function networks had been used to diagnose Multiple Sclerosis. They provide an automatic, fast and reliable way to discriminate the signals from sick and healthy people. But it seems that the results differ according to the method used for the training of the neural network. But since this was the result of only one specific network architecture, with a specific method of expanding the training set, further investigation is needed to determine if this result is similar when we use a different artificial network, and/or expand the set of training elements applying a different technique, and/or we use a different random generator that MATLAB supplied.

To answer these questions we should first allow to modify the number of hidden nodes. This will increment the number of centers and radii, and it will constraint the number of input nodes. We could probably assume that the first coefficients that discriminate more are enough to convey most of the \hat{R}_k information, and selecting a larger number does not enhance the learning of the network. But on the other hand, we should be

careful when the number of hidden nodes is so large that the number of input nodes goes below 8. It seems that in this case we will not be able to capture enough discriminating features of the input space. [19].

Another point to highlight is that table 1 has a great variety of averages, and standard deviations. Table 2 shows small differences in the averages, and most of them with very low or zero standard deviation. But in this last case, the standard deviations reach big values while using some wavelet, as mentioned above.

For future research, we could compare these results to those obtained by using a different statistical discriminating criterion, like the largest sum of the absolute value of the coefficients, the principal components analysis, the Wilcoxon rank sum test, or Shannon's entropy.. We could also apply the expanding of the training set according to [17] using the original values of the 512 points instead of the coefficients of the discrete wavelet transform. Or we could increment the number of training elements using white noise applied to the original signals. We could also change the number of hidden nodes, with the corresponding variation of the number of input nodes, to avoid overlearning. With respect to the artificial neural network that we have used, we could investigate if the removal of the bias hidden node would affect the result.

We could also use a margin based feature selection criterion and apply it to measure the quality of sets of extracted features [23]. Another possibility is to pass a message between the different particles at various level of training. Finally we could select the even or odd values in the set of original data when they are expanded using cubic splines. This will generate twice as many numbers of start data for the randomly generated expanded training set. Of course we could use a combination of all these approaches to compare the results with those obtained in this paper.

In conclusion we can say that our findings are a good sign that artificial neural networks with radial basis functions could be used to help doctors when they are diagnosing cases of multiple sclerosis

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Design of Pulse Oximeter with WiFi connectivity and interoperability with standard HL7 and IEEE 11073-10404:2008

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ABSTRACT

Given that health is so relevant for global productivity and competitiveness, and that the ICTs play an important role in all of the productivity factors, this work makes use of the ICTs in health matters proposing the to use a WiFi oximeter. This article describes the operating principles of a Pulse Oximeter (PO) which is an opto-electronic non-invasive medical instrument capable of measuring changes in HR and SpO₂ at the fingertip and its upgrade to the standards; HL7 and IEEE 11073-10404:2008, its design, and its validation against the three existing devices. Variables (SpO₂%, Ppm, Temperature) were compared, and its performance and impact were discussed the addition of the WiFi technology allows a better comunication between devices, causing a greate impact in global competiveness.

Keywords: HL7, OBX message, Pulse Oximetry, Optical Sensor, Heart Rate level, WiFi protocol.

1. INTRODUCTION

Health is very important to be a competitive person in a world like ours, so this paper is related about a biodevice (Oximeter WiFi) for health. Pohjola, Venturini (2009) say that ICT investments have a positive impact on economic growth of GDP, also Edwards (2001) said that areas need large investments in ICT research, development, education, infrastructure and health to generate economic growth. Baily, Katz and West (2011) suggest that investment of ICT innovation as a key factor in the economy, so we can say that the oximeter is a technology that can help economic growth regardless of health satisfier. [2-3], [4], [5].

The pulse oximeter has become a vital NICU instrument [15], [16] and may have been adopted as a standard [17]. Various studies have concluded that with better technology, pulse oximeters would provide highly accurate measurements of oxygenation[17-18]. Bierman demonstrated that with other factors being equal, pulse oximetry significantly reduced the need for arterial blood gas collection [17], [19-20]. Zengel examined the effects of subareolar isosulfan blue injection on pulse oximeter (SpO₂) readings and concluded that Time to peak SpO₂ fall, and the recovery period, are delayed in the subareolar technique [21].

On another hand Rodríguez, Garrido, Martínez, & García (2013) presented a paper related to the accuracy of pulse oximeters, including a brief introduction to the pulse oximetry operation principles, calibration procedure, and discusing the main aspects related to the accuracy of measurements and staying that the magnitudes of the errors due to variations of the wavelengths of the LEDs used were highlighted together with the risks that those errors produced to the patients [1].

Hülsbusch, et. al (2010) studied cardiovascular diseases of irregularities in the human cardiovascular system developing a miniaturize in-ear pulse oximeter, based on a micro-optic in-ear sensor. The resulting signal was then transferred wirelessly to a personal digital assistant (PDA) smart phone or PC where the heart beat, oxygen saturation (SpO₂), breathing frequency and slower perfusion rhythms could be calculated. This contribution introduced the system concept of the monitoring [13].

Besides, the oxygen is vital to the functioning of each cell in the human body. Without oxygen for a prolonged amount of time, cells will die. Thus, oxygen delivery to cells is an important indicator of a patient health. Several methods have been developed to analyze oxygen delivery. Pulse oximetry is a common, noninvasive method used in clinical environments [6].

Blood red cells contain a protein called hemoglobin. Red cells with oxygenated hemoglobin circulate in the blood through the whole body, irrigating tissues. When blood gets in contact with a cell, the red cells hemoglobin releases oxygen and becomes Deoxyhemoglobin (Hb) (deoxygenated hemoglobin) [7].

More over pulse oximetry is the non-invasive measurement of the oxygen saturation (SpO_2) . And pulse oximetry systems are based on two principles related to the characteristic of blood flow rate in the context of the oxy-hemoglobin and deoxyhemoglobin status. Both oxy-hemoglobin and deoxyhemoglobin are different in their absorption of red (660 nm to 750 nm) and infrared light (850nm-1000nm), and because the volume of the arterial blood in tissue changes as the pulse changes. With each heartbeat, the volume of the arteries becomes larger before the blood enters the capillaries. This change makes possible for the oximetry system to differentiate the arterial blood from all other absorbing substances [8], [9].

When light is emitted into the body tissue, some light will be absorbed by the skin, bones and muscle tissue. This represents the static direct current (DC) component of the signal received at the photo detector receiver. The pulsatile flow in arteries and arterioles during diastole and systole will create some variation in light intensity. This will produce the alternating current (AC) part of the signal [9]. At this point the absorption that occurs is known as the Beer-Lambert Law. Both AC and DC components are shown in Figure 1. [10].



Fig. 1. Light absorption through living tissue

As mentioned above, we agree with Shafique, Kyriacou, & Pal (2012), who investigated Photoplethysmography (PPG), a technique widely used to monitor volumetric blood changes induced by cardiac pulsations. Pulse oximetry uses the technique of PPG to estimate arterial oxygen saturation values (SpO₂) [14].

2. DESCRIPTIVE AND METHODOLOGICAL SECTION

This research was supported by an experiment, at the "Hospital de Ortopedia y Traumatología - Dr. Victorio de la Fuente Narváez" in Mexico City, in 2013, with a sample of 32 patients. The experiment consisted of taking samples of variables 1) $SpO_2\%$, 2) Ppm and 3) The temperature, which are shown in Figure 8 and are described in Table 1. The measurement were taken by three diffente devices: Nonin, Mazimo, and WiFi oximeter.

Table 1. Study variables

Variable	Description
SpO ₂ %	Oxygen level (0 to 100%)
Ppm	Pulses per minute (0 to 200ppm)
Temperature	Body Temperature (0 to 100°C)

An intensive care monitor alarm has been a major burden on both nurses and patients. Between 44% and 63 % of alarms are caused by pulse oximeters, with 94 % of these being nonsignificant [22-24]. Any technique for measuring pulse oximeter saturation (SpO₂) has been developed using a mathematical manipulation of the pulse oximeter red light and infrared light absorbance to identify and subtract the noise components associated with these signals [25]. Theoretically the pulse oximeter analyzes the light absorption of two wavelengths from the pulsatile-added volume of oxygenated arterial blood $(AC_{red light}/DC_{infrared light})$ and calculates the absorption ratio "R" using the following Eq. 1.

$$R = \frac{AC_{660}/DC_{660}}{AC_{940}/DC_{940}} \tag{1}$$

SpO₂ is taken out from a table stored on the memory calculated with empirical formulas. A ratio of 1 represents a SpO₂ of 85%, a ratio of 0.4 represents SpO₂ of 100 %, and a ratio of 3.4 represents SpO₂ of 0 %. For more reliability, the table must be based on experimental measurements of healthy patients.

Another way to calculate SpO_2 is taking the AC component only of the signal and determines its ratio by using Eq. 2. SpO_2 is the value of "R" X 100.

$$R = \frac{Log_{10}/(I_{AC_{660}})}{Log_{10}/(I_{AC_{940}})} X100$$
(2)

Where:

 I_{ac} = Light intensity at 1 (660 nm) or 2 (940 nm), where only the AC level is present.

R= Absorption ratio of light.

The system consist of five parts; sensor, amplifier, processing, LCD display and WiFi communication protocol, as shown in Figure 2.



Fig. 2. Block diagram showing the flow of operation for the Pulse Oxymetry WiFi System

Sensor of Pulse Oximetry



Fig. 3. Sensor orientation for light transmittance in the designed pulse oximeter.

The WiFi Pulse Oximeter system have a probe (sensor), is composed by two LEDs, and a photo-detector. The two LEDs used in the sensor part are the red and infrared (See Figure 3), and the signal collected by from the photo-detector. To perform our tests, we used the finger. The detectors must be highly sensitive and be able to measure the weak emission through to the tissues.

Acquiring the signal

The optical receiver element is a photodiode. The adquisition of the signal is obtained by amplifing and filtering the output of the phodetector. The amplified photcurrent is a moderatevoltage, low-impedance output, which is then taken to a bandpass filter section designed to operate at frequencies of 0.15 Hz to 7.5 Hz. This is mainly intended to eliminate the DC component and high frequency noise, as seen in Figure 4. [12]



Fig. 4. Filtering and Amplifying Circuits.

Processing Pulse Oximetry Signal

The aquired is supplied to a Programmable Interface Controller (PIC) which will be converted it from analogue into digital signal through the built-in 12bit Analogue to Digital Converter. However, this convertion requires a C programming software and C18 compilation process to generate the Hexadecimal ".hex" file. An example of line code in C18 to calculate de SPO₂%, applying (2) is given in Eq. 3

calculoSpo2 = (((log((1 / red))) / (log((1 / infrared))))*100); (3)

Display of Pulse Oximetry

For the device to be user friendly, the measured values are shown; the output produced by the PO will be displayed via a Liquid Crystal Display (LCD) screen. The organization chacters are as shown in Figure 5.

1	2	3	4	5	6	7	8	9	10	11	12	13	- 14	15	16
Ρ	р	m	=				S	р	0	2	%	=			
Т	e	m	р	=			Ρ	r	е	=	n	0	r	m	

Fig. 5. Display test data processed as the Table 1

The WiFi protocol and communication

The implementation of the WiFi protocol uses the Microchip TCP/IP Stack, a suite of programs that provides services to standard TCP/IP-based applications (HTTP Server, Mail Client, etc.). The software stack has an integrated driver that implements the API that is used in the modules for command, control, management and data packet traffic [11].

When the device has the final results (SpO₂% and the HR), we use a micro embedded WiFi card to communicate the microcontroller with the most nearest access point (AP) to enable the WiFi Pulse Oximeter system to be reachable for other devices like laptops, computers, Smartphones connected to the same AP, as shown in figure 6.



Fig. 6. Oximeters with WiFi connectivity over the network

The standars; HL7 and IEEE 11073-10404:2008

It is esential for systems such as health devices, to interoperate among each other to have a common comunication standard. The ISO/IEEE 11073 family of standards for medical devices has existed for many years and was originally developed for hospital based equipment and specifically for the intensive care environment. The original protocol, based on the full OSI 7 layer model, was often criticised as being heavyweight and complex. In its current form, it was not considered appropriate as the basis of a new standard for personal health data (PHD) devices. [27]

In oder to solve interoperability among PHDs, a non-profit organization involved in the development of international health care informatics interoperability standars, brought out the Healt Leve Seven (HL7) standar (e.g., HL7 v2.x, v3.0, HL7 RIM).



Fig. 7. Overview of the IEEE PHD 11073 Framework.

Once the results were ready to be transmited, the standard IEEE 11073-10404 [28] was used to create a data frame, which contains the variables: idDevice, date and time, idMeasure, deviceSerialNumber, wifiMacAdrees, batteryState, temperature, spo2, ppm, etc. All those data were pakaged into an OBX (Observation Segment) message, which is a segment used to transmit a single observation or observation fragment. It represents the smallest indivisible unit of a report. It is used to comunicate trough all the platforms, who uses the Health Level Seven (HL7).

3. IMPLEMENTATION

Following [26], measurments were taken by three devices (Nonin, Mazimo and WiFi Oximeter), SpO₂% values below 95% where, then by a second measurement, and only the highest value was recorded.

The first implementation was made at the "Hospital de Ortopedia y Traumatología - Dr. Victorio De La Fuente Narváez" in Mexico City, with optimum results at the moment of testinf the WiFi Oximeter [8]. All tests were reviewed by specialist doctors under the ISO 9919:2005, in which ISO defines the procedure to prove the Oximeters. [14] Figure 8 shows the tests.



Fig. 8. Oximeters test; Mazimo, Nonin and Oximeter WiFi in a patient.

4. RESULTS AND DISCUSSION

The results obtained from the three devices Nonin, Mazimo and Oximeter WiFi, are quite similar as shown in Table 2. Regarding the temperature, only the WiFi Oximeter device, Table 2 shows the values.

 Table 2. Results from the Three Treatments

	Nonin		Mazimo		Oximeter WiFi		
	SpO ₂ %	PPM	SpO ₂ %	PPM	SpO ₂ %	PPM	Temperature
Min.	87.00	70.00	86.00	69.00	86.00	70.00	29.00
Max.	99.00	94.00	100.00	93.00	100.00	94.00	32.00
Average	94.16	82.84	93.72	82.78	93.78	83.00	30.38





Fig. 9. Test Results SpO₂%

Discussion: Many authors have stated the need of interoperability aiming to obtain fast and realive masurements. Aditionally, as observe in Figure 8, though the similarity of the measurements the WiFi Oximeter device gives the temperature, which can be consider as an added value. This would promote an econimich growth of the Health Care Industry by having low-cost, hight-reliable measurement devices obtaining more varibles, as pointed out by Pohjola [4] and Venturini [5].

5. CONCLUSIONS AT THE MOMENT

The preliminary conclusions are: **First**, from the electronic point of view: the needed research and tests were carried out to join the project and brought it to a first phase, its construction. **Secondly**, notwithstanding that results were successful in its implementation, doctors made it clear that further testing in a more specialized area is needed, and of course, this is a more advanced version of this oximeter. Because doctors **asked if the oximeter could autosave the results into a system or database and the answer was yes**, this question gave us the opportunity to develop as a second phase of the oximeter. The features are emphasized: scalable technology, on-line monitoring, provides connectivity and networking, will provide more timely and easy monitoring, use of Standard ISO 9919:2005, standard HL7 and IEEE 11073-10404:2008 and others. This design is protected in Mexico by the Patent, Number: MX/u/2009/000216.

6. ACKNOWLEDGEMENTS.

The authors would like to take this opportunity to express his heartfelt appreciation and thanks to the Instituto Politecnico Nacional and the UPIICSA, IMSS especially to the Hospital de Ortopedia y Traumatología - Dr. Victorio De La Fuente Narváez for their support, which made it possible for the authors to produce this paper.

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Protein Sequence Analysis and Boundary Detection of Functional Domain

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ABSTRACT

Domains are fundamental evolutionary units possessing distinct functions and/or structural conformations of proteins. Most of proteins contain multiple domains, which are formulated through gene duplication events and likely caused by a selective pressure during evolution. Different domain combinations of a protein involve in important protein-protein interactions during cell-cycle regulation, and any mutation within a functional domain might result in abnormal folding in proteins leading to serious diseases. Hence, accurate prediction of domain boundary provides the first step towards the studies of protein structure stability, functional annotation and evolutionary biology. In this study, we have collected comprehensive protein sequences and corresponding domain annotations as the referencing and training datasets. Based on selective features of sequence length, distribution of secondary structure elements, and amino acid combinations, the proposed system employed sequence alignment and support vector machine (SVM) clustering methods to identify locations of protein domain boundary. The results have shown that a recall rate of 90.7% and a precision rate of 86.4% could be achieved for 1868 protein sequences collected from representative proteins in PDB database based on blasting sequences in referencing database, and an accuracy rate of 73.15% based on SVM techniques through a 10-fold cross validation.

Keywords: Functional domain, Domain boundary, Amino acid pairs, Secondary structure element, SVM.

1. INTRODUCTION

A protein domain is considered as a conserved functional unit within a given protein sequence or a structure that could be discovered from the homologous proteins or functional derivatives of proteins. Since a protein domain is a fundamental unit in evolution of protein functions [1], identification of protein domains is considered as the first step for protein function analysis and prediction of protein structures. Proteins are frequently found with multiple domains or a combination of repeated domains [2]. Different domain combinations affect structure stabilities and involve in protein-protein interactions at every stage during cell cycle regulation.

Recent studies on interdomain boundaries have shown that the importance of boundaries in maintaining normal domain-domain interactions [3]. An example of deleting 4 amino acids from the interdomain connecting two domains of phosphorylated smooth-muscle myosin would result in a termination of actin translocating activities [4]. We observed that not only the residue composition of interdomain boundary affects stability of protein structures, but also the length and flexible secondary structures of a boundary. Therefore, we collected abundant protein sequences in this study to perform statistical analysis, especially focusing on features of composition of amino acids, secondary structure elements, and lengths of interdomain boundaries. According to trained features, the propose method can effectively and automatically classify domains or interdomain boundaries through machine learning approaches.

In this study, we combined sequence homology and machine learning methods for interdomain boundary Since most of protein sequences lack prediction. structural information, we applied a sequence alignment approach for primitive domain detection from homologous information. Unfortunately, primary sequence alignment could not solve the problems when query sequences possessing low sequence similarity compared to referencing databases. To overcome such a limitation of traditional sequence alignment, a secondary structure prediction tool was adopted to define corresponding secondary structure information. Besides, the library of SVM tool (LIBSVM) [5] was applied to recognize features of domains and interdomains. This paper aims to combine two methodologies including homologous sequence-based and machine learning techniques, and all details will be discussed in the following sections.

2. MATERIAL AND METHOD

2.1 Data Collection

We collected protein domain sequences from Pfam (v.25) [6] which is a well-known protein database including functional domain information and protein family annotations. In this study, we only employed Pfam-A dataset with 12,273 protein families for domain assignment and identification of domain boundaries. To identify interdomain boundaries within unknown protein sequences, a domain unit dataset was manually constructed as a reference through homologous alignment. The classification in Pfam-A was based on domain functions of sequence fragments rather than structural characteristics. Seed alignments in Pfam-A were manually curated by experts by aligning representative sequences within a protein family, and these calibrated dataset was applied our benchmark dataset for local sequence alignment and domain assignment.

2.2 Identification of Interdomain Boundary

Identification of protein domain or interdomain boundary requires a clear definition for each application. However, from different published reports, domains and interdomain boundaries were defined in different ways. Such as definitions in both well-known structure databases of SCOP [7] and CATH [8] are different. Thus, different definitions of domain regarding protein structure, function and evolutionary information could be used to develop various methods of prediction. Furthermore, definitions of boundary were also varied in different studies. For example, in DROP [9], domain boundary is a loop region separating domains without α -helices and β -strands; DOMPro [10] denoted residues within 20 amino acids of a boundary as the domain boundary; DoBo [11] defined a domain boundary by recognizing the first and the end residues of domains. Here, a domain boundary is defined as interdomain fragments as the definition in Pfam-A

2.3 Protein Sequence Analysis

Several protein domain prediction studies based on known domain structures provided higher accurate rates than other sequence-based methods. The drawback is that the prediction accuracies decreased when a protein domain is not well conserved in sequences and/or not yet deposited in the fundamental database. One protein domain is a functional block of a protein, the composed residues of such a domain may occur in many different proteins, which might possess with same or similar functions. Therefore, we tried to analyze various characteristics of domains from protein sequences and to detect the differences between domain segments and interdomain boundaries. In this study, we integrated domain sequence information including residue property, domain length distribution, and composition of secondary structure element to realize the identification of interdomain boundary.

2.3.1 Analysis of Amino Acids Pairs

Amino acids were combined to form proteins and play a central role of protein functions. The 20 amino acids within proteins possess specific physic-chemical properties, and single mutation in a protein sequence may damage its function. Moreover, properties of amino acids determine the biological activities of a protein through various folding mechanism to form a protein structure. Hence, we analyze the compositions of amino acid pairs, called AAPs, to estimate all distributions in domains and interdomain boundaries in order to understand the distribution of AAP tendencies. Previously collected protein sequence database were applied to extract both domain and interdomain segments separately according to definitions in Pfam-A. A total of 400 possible combinations were analyzed for occurrence frequencies within both domain and interdomain regions, the relative frequencies were calculated according to the following equation:

$$\mathbf{S}_{i} = \log \left[\left(\frac{ID_{i} / \sum_{i} ID_{i}}{D_{i} / \sum_{i} D_{i}} \right) \times 100\% \right]$$
(1)

where D_i and ID_i were the number of the *i*th AAP in domain and interdomain regions; $\sum_i D_i$ and $\sum_i ID_i$ denoted the total number of the *i*th AAP in the corresponding dataset; S_i were normalized to the range [0, 1]. An AAP tends to occur in interdomain boundary while the relative score S_i has a value bigger than 0, and S_i less than 0 for occurring in domain areas. To find trends of 400 combinations of AAP, we presented the calculated results with a 20x20 matrix. The statistics shows that the combinations with either amino acids Lysine(K) or Proline(P) possessed S_i values larger than zero and tended to occur in interdomain boundaries.

2.3.2 Statistical Analysis of Domain Lengths

Domains vary in length from about 25 to 500 amino acids. Past works indicated that a protein may consist only one domain, while most of proteins are formed with two or more domains. We considered that domain length distribution is an important clue for distinguishing proteins containing one or multiple domains prior to identifying domain boundaries. If a protein is decided as a single domain protein, it would not be necessary for detecting domain boundaries. Therefore, statistics of domain length is applied initially. Pfam-A classified protein families into 4 categories: the first two types of "Repeat" and "Motif" are frequently appeared continuously to form as domain repeats structures, and the last two types of "Domain" and "Family" are non-repeat mechanisms with more stable structure compared to previous two types. Here, we selected multiple domain sequences from Pfam database and calculated the length frequencies of four different types of proteins. The result showed that the lengths of protein domains are concentrated in the range of 90 amino acids or less. Therefore, we assumed that if a protein contains two or more domains, it should be with a length more than 180(90x2) amino acids. According to the assumption of domeain length and interdomain boundary segment, this study assumed that a minimum length of a protein sequence with 200 amino acids is a minimum length for predicting the locations of interdomain boundaries .

2.3.3 Secondary Structure Characteristics

It has been noted that an interdomain boundary is majorly comprised with specific secondary structure of loop elements. Investigation of protein secondary structure provides another feature for identifying interdomain boundaries. Here we applied the definitions of secondary structure element from PDB[12], mapping protein sequences in Pfam onto PDB protein structures to retrieve all secondary structure information. To explore the characteristics of secondary structure in domain boundary, we followed the same approach in previous approach for primary sequences by considering two consecutive secondary structure elements within a boundary region and called as SSE pairs. The distribution of SSE pairs has shown that the combination of loop-loop element possessed the highest occurrence rate in domain boundary, and followed by helix-helix pairs. Occurrence frequencies of these 9 combinations were normalized into the range of [0, 1], and the frequencies were applied as one of the features of interdomain boundary. Similarly, we applied the secondary structure information to calculate the length distribution of loop elements within domain boundaries and the results showed that the major loop length possessed 4 amino acids or less. The loop length was considered as another feature for identifying interdomain boundaries.

2.4 Interdomain Boundary Analysis

The length of interdomain boundary affects the stability of protein structure, arrangements of neighboring domain, and even the ability of protein-protein interactions. Here we applied the length information from Pfam-A database, and length of interdomain fragments was observed that the sequence length of interdomain boundary were mostly located within 30 amino acids. Thus, we assumed the default boundary length as 30 amino acids, and it is also the default window size in subsequent machine learning method for classifying domain and domain boundary peptides.

2.5 Identification of Interdomain Boundaries

A data flow chart for automatic identification of interdomain boundary is shown in Figure 1. First, a protein with minimum sequence length of 200 amino acids is required. Then, the query sequence was aligned to the representative sequences from Pfam-A by BLASTP algorithm with E-value of 0.001 and default parameter settings. If more than two segments could be matched from the domain unit dataset, these aligned segments are considered as domain segments within the query sequence. However, if no aligned result was obtained from previous procedures, a secondary structure prediction and machine learning technique would be employed for domain/domain boundary analysis. In this step, a secondary structure prediction tool, SSPro4[13], was adopted to assign SSE information of the query sequence. To predict interdomain boundaries, a window of 30 amino acids would scan through the query sequence. For each residue in the window, the feature of AAPs, SSE pairs and loop length of boundary were calculated. Finally, the system employed the open source LIBSVM tool for classifying the boundary prediction.

2.6 Machine Learning by SVM

In this study, we applied support vector machine (SVM) for boundary classification. We adopted the open source tool of LIBSVM which is an integrated and easy-to-use tool for multiclass classification, regression and distribution estimation. In LIBSVM, each example of the training dataset must contain one target value with defined class label and several features with corresponding values. Due to long-term evolution, low sequence similarities of a homologous domain might not be successfully detected through sequence alignment against database. Hence, we applied learning mechanism to enhance the accuracy of prediction of domains and/or domain boundaries. In this study, we parsed definitions of domain and domain boundary sequences annotated in Pfam-A, and two datasets were created for training by SVM. The LIBSVM generated a clustering model from training sets and applied to testing data by assigning a value of 0 or 1. The assigned value of 0 represented the testing example belonged to domain boundaries.



Figure 1. Flowchart of interdomain boundary identification.

2.6.1 SVM Features

In training sets, the features were calculated from a scanning window of 30 amino acids, and AAPs located in the central parts of window belonging to either domains or domain boundaries were assigned with a the target value of 1 or -1. Hence, a scanning window of 30 amino acids could be decomposed into 29 AAPs. The feature values were obtained by multiplying the relative fraction S_i of each AAP and the occurrence times of corresponding AAPs. For example, a length with 30 amino acids sequence, "MRGSHHHHHHTD PHASSVPLEWPLSSQSGS", is decomposed into 29 AAPs including MR, RG, GS, SH, HH, HH, HH, HH, HH, HT, TD, DP, PH, HA, AS, SS, SV, VP, PL, LE, EW, WP, PL, LS, SS, SQ, QS, SG, and GS, of which GS, SS, and PL repeated twice and HH repeats 5 times. Then, the relative fraction S_i of each AAP multiplied by occurrence times of corresponding AAPs respectively to receive its corresponding feature values. After appropriate calculation, we could obtain relative fraction S_i of the corresponding AAPs in each segment and employ them as the features of the designed SVM classifier. Similarly, the feature values of SSE pairs could be obtained by applying the same approach. In addition to the property of residue combinations, we also measured loop lengths in the scanning window as the final feature. An SVM model was then constructed by training these feature values from the training dataset.

We collected all representative proteins in PDB, which were defined with sequence identities less than 30% for each pair of proteins, and the domain information of selected proteins agreed in SCOP(v 1.75). Any protein with sequence length less than 200 residues was removed. This resulted in a data set of 1868 non-redundant protein sequences that were applied as a training and validation set for SVM. We evaluated the proposed method by a 10-fold cross validation. Besides, there were four kernel functions provided by LIBSVM including linear, polynomial, radial basis function (RBF), and sigmoid. Here, we selected linear kernel function as the default kernel function in

this study since it provided the best accuracy on the training dataset. Finally, the average of ten individual classification accuracies was calculated to validate the performance of the proposed model. For the system evaluation, we applied both recall rate and positive predictive rate. The recall rate (or called sensitivity) and precision rate (or called positive predictive value) were applied to evaluate the performance of our proposed method of interdomain boundary identification. A recall rate measures the proportion of actual boundaries which were correctly identified as boundaries; a precision rate represents the probability of predicted boundaries which are really domain boundaries.

3. RESULTS

In order to measure the performance of sequence comparison of BLASTP, we applied the collected 1868 protein sequences as a testing/validation dataset which possess multiple domains and with sequence identities less than 30% for each pair of protein. Subsequently, we calculated the proportion of detected domains which were different from actual domain locations within 30 amino acids. Table 1(a) listed the actual domain positions for an illustrated example of 1a9x:A and the detected domain positions by sequence alignment approaches. The accuracy of this example achieved 83.33%. For all testing protein sequences, there were a total of 4246 domain segments correctly found, 436 domain segments failed to be detected, and 633 segments misrecognized as domain segments. Thus, the recall rate and precision rate were 90.7% and 86.4% respectively. All the measurements were presented in Table 1(b). In addition to boundary prediction by blasting sequences, an alternative approach based on selective features and SVM clustering techniques was evaluated in this study. According to three features of AAPs, secondary structure elements, and distribution of domain length, a trained model was constructed and evaluated through a 10-fold cross-validation. These 1868 collected protein sequences were applied for system evaluation, and an accuracy rate of 73.15% was obtained for the domain and domain boundary classification. In the other words, if the query protein could not be aligned to known domain segments due to low sequence similarity, we adopted LIBSVM for domain/domain boundary identification according to the previously selected features.

Table 1. (a) Aligned results for an example of 1a9x:A. The actual locations of domains with starting and ending positions and correctly identified domains by BLASTP. (b) The sequence alignment results of 1868 protein sequences. We calculated the recall and precision rate of those sequences BLAST with domain unit dataset.

PDB ID 1a9x:A	Residue number of domains								
Defined by	6 -	128 -	424 -	558 -	674 -	956 -			
PDB	123	335	547	669	877	1042			
BLAST	6 -	128 -	424 -	558 -	674 -	Х			
results	123	335	547	669	877				
Precision	5/6 = 83.33%								

(a)

Correctly identified domain segments	4246
Segments failed to be detected	436
Mis-recognized segments	663
Recall rate (%)	4246 / (4246+436) x100% = 90.7%
Precision rate (%)	4246 / (4246+663) x100% = 86.4%

(b)

4. DISCUSSION AND CLOCLUSION

In this study, we have designed a combination method including homologous sequence alignment and machine learning technique to identify interdomiain boundary. According to previous studies that demonstrated protein domains were likely to be conserved through evolution, we initially applied BLASTP algorithm to evaluate highly conserved segments through sequence comparison. If query sequence possessing low sequence similarity against collected domain sequence, the proposed system performed statistical analysis on amino acid pairs, secondary structure pair, and length of loop element for machine learning based method to perform interdomain boundary identification. We have demonstrated that there are several features could be applied to classify the differences between protein domains and interdomain boundaries. In the proposed method, both AAPs and SSE pairs are applied as key characteristics for domain and interdomain boundary identification. The low recall rates were mainly due to tandem domain segments which containing short interdomain regions such that two neighboring domain segments might be considered as one domain. Hence, if we could explore specific features for tandem repeat domains, or add extra physical and chemical properties of amino acids for learning model, we could expect a better recall rate could be exceptionally improved.

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Acknowledgements

This work is supported by the Center of Excellence for Marine Bioenvironment and Biotechology of National Ocean University and National Science Council, Taiwan, R.O.C. (NSC NSC102-2627-B-019-003, NSC101-2321-B-019-001 and NSC 100-2627-B-019-006 to T.-W. Pai, and NSC103-2325-B-007-007 and NSC103-2622-B-007-001-CC1 to Margaret Dah-Tsyr Chang)

The Impact of Using Challenges and Competitions in the Workforce

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ABSTRACT

Federal agencies are seeking new ways to innovate, procure and enhance enterprise capabilities. Competitions are one tool that federal agencies can use to drive innovation and solve mission-centric problems—whether technical, scientific, or creative. In this paper we present an examination of several approaches to foster open innovation through challenges and competitions in support of key business operations in the workforce. We highlight specific examples of their use in "real world" environments and provide an assessment of applicability, benefits and challenges for implementation in large organizations.

Keywords: Continuous Innovation, Challenge-Based Acquisition, ChBA, Competitions, Gamification

1. INTRODUCTION

In a previous paper, we introduced several alternative approaches as well as advantages and limitations related to using competitions and games as a method to advance research and acquisition for continuous innovation [2]. We proposed that an effective way to motivate crowds of innovators is to provide a challenging game or competition to achieve results. Additionally, we showed that competitions are an effective technique for maturing state-of-art research or for executing down-selects in acquisition processes [9]. These findings were in line with recent Government guidance for increased use of challenges and prizes to develop new tools and approaches to improve open government. [12]

In this paper we present a follow-on examination of several approaches to foster open innovation through challenges and competitions in support of key business operations in the workforce. We highlight specific examples of their use in "real world" environments and provide an assessment of applicability, benefits and challenges for implementation in large organizations.

2. BACKGROUND

In the past conferences, we discussed approaches to foster open innovation, including the use of crowds and social media for continuous innovation [2, 3]. Specifically examined where, emerging trends and technologies that would have an impact on open innovation, as well as an examination of the evolution of innovation to understand attributes and patterns for its success and/or failure. We found that with the emergence of social computing, an explosion of open innovation, crowdsourcing, and competitions [6, 7]. In fact, since 2010, over 58 federal agencies have run more than 300 challenge competitions [13, 14].

Government and industry have long used challenge-based acquisition (ChBA) to spur technology. For example, the Defense Advanced Research Projects Agency (DARPA) has encouraged advances in unmanned ground vehicles by sponsoring three Grand Challenges with multi-million dollar prize pools [5]. More than 100 teams showcased their ideas for autonomous automobiles in the 2004 Challenge. In 2012 DARPA launched its Robotics Challenge to promote the development of autonomous The National Aeronautics and robotics. Space Administration's (NASA) Centennial Challenges have triggered an outpouring of creative solutions from students, citizen inventors, and entrepreneurial firms for technologies such as lunar landers, space elevators, fuelefficient aircraft, and astronaut gloves. The Department of Energy has sponsored the L Prize, designed to spur the development of high-quality, highly efficient solid-state lighting products to replace today's inefficient light bulbs. The Environmental Protection Agency has used prizes to encourage students and others to develop videos to promote environmental stewardship. [12]

Such challenges bypass traditional federal acquisition methods built around stringent specifications, lengthy development cycles, and arms-length vendor relationships. Instead, the ChBA process promotes a competitive environment, demonstrated performance, and an increased partnership with industry. In recent years, MITRE has collaborated on ChBA initiatives to promote advances in improvised explosive device detection and network integration evaluation [8]. We're working with our sponsors to continue to integrate ChBA into their acquisition processes, policies, and guides. MITRE is also partnering with other Government customers to support the wider use of challenge-based acquisition [1]. In this paper, we will focus on the use of challenges and competitions, and how they can be used to foster a robust acquisition strategy.

3. THE POWER OF THE CHALLENGE

Traditional acquisition processes often require a deep understanding of requirements and a profound knowledge of the potential solutions that are available in the market place. Traditionally federal acquisition approaches tackle this challenge by conducting a market analysis prior to formal acquisition activities. The results of these analyses are then used to scope the technical procurement There are instances when the lack of approach. understanding of the potential solution space may preclude the development of a market analysis. In these cases, the use of challenges or competitions has proven useful. Some have even chosen to conduct ChBAs in a contest-like manner to encourage greater innovation and private sector participation, when the payment of a prize is for a good or service for the benefit of the government. At its core, the use of ChBA, allows the government to communicate its needs through challenges that are analogous or identical to a desired capability. Then, industry would respond to the challenges without extraneous constraints. In turn, these challenges can abstract away irrelevant concerns and can in many cases be substitutes for loose requirements [11].

In our experience, we have observed the use of such methods in support of common business operations throughout the workforce:

- **Innovation**: seeking to spark new ideas to hard problems.
- Acquisition: seeking new ways to acquire capability.
- Capability Assessment and Evaluation: Assessing user experience or functional utility and readiness of products and capabilities.
- **Hiring Qualified Employees**: seeking new approaches for finding and evaluating high quality candidates, conducting interviews and hiring to build corporate talent pipelines.

The basis for ChBA can be found in the application of game theory, or "gamification" [10]. Gamification is the

use of game thinking and game mechanics in non-game contexts to engage users in solving problems. Gamification has been studied and applied in several domains, such as to improve user engagement, physical exercise return on investment, data quality, timeliness, and learning. A review of research on gamification shows that most studies on gamification find positive effects from gamification.

4. EXAMPLES IN THE WORKFORCE

There are many examples in literature of organizations using challenges and competitions [4]. In this section, we provide several examples based on our personal experience of using such methods in support of key business operations in the workforce, specifically in the Government or our own organization, MITRE.

Innovation: The following are example highlights a Government project seeking to spark new ideas to hard problems.

Challenge.gov is a government challenge framework administered by the US General Services Administration (GSA) and based on the commercial Challengepost.com technology [13, 14]. Challenge.gov is a collection of challenge and prize competitions, all of which are run by more than 50 agencies across federal government. These include technical, scientific, ideation, and creative competitions where the U.S. government seeks innovative solutions from the public, bringing the best ideas and talent together to solve mission-centric problems.

The Challenge.gov platform provides a central, online space for agencies to post challenges, and at the same time, allows the public to find federal challenges. This is the one-stop repository for the public to discover and engage with federal agencies that are running crowdsourcing competitions. As part of this, the Ideation competition platform is designed for agencies to host crowdsourcing contests that solicit ideas and concepts from the public. All of these competitions are listed on challenge.gov.

<u>Acquisition</u>: The following example highlights a Special Operations Command (SOCOM) Government project using challenges and open innovation as part of seeking new ways to acquire capability.

SOCOM has a long-term goal to develop technologies to meet Special Operations Forces (SOF) mission requirements. The Tactical Assault Light Operator Suit (TALOS), is a vision to integrate science and technology (S&T) capabilities into an integrated suit that better protects a warfighter and/or first responder. The intent is to accelerate the delivery of these innovative capabilities to the warfighter. Prior studies and analysis have determined a number of technical challenges exist that require improvements in equipment for future missions, such as 1) balancing the trade space between weight, protection, power, mobility, 2) cost, and 3) system component integration. A TALOS suit would comprise layers of smart material, sensors, communications radios and other capabilities for better enabling and protecting soldiers during combat situations [16]. Example technologies being explored include, but are not limited to advancements in:

- Advanced Armor
- Mobility/Agility
- Situational Awareness (SA)
- Light/Noise Disciplines
- Command, Control, Communications & Computers (C4) Integration
- Individual user helmet displays
- Power generation and management
- Thermal management of suit occupant
- Medical Services

The Government is seeking innovations from industry, academia, individuals, and Government Labs capable of providing the design, construction, and testing of TALOS related technologies. It is an interactive process designed to assess the viability of technologies while simultaneously refining user requirements. They are using Google hangouts, monster garage "hackathons", and technology workshops to motivate the entire community to team and work together throughout the innovation process. As solutions mature, the most viable options will be selected as the reference implementation for acquisition.

<u>Capability Assessment and Evaluation</u>: The following example highlights the use of challenge events by a Government Intelligence Community Sponsor to assess user experience or functional utility and readiness of products and capabilities.

By using challenge events, vendors can show that they understand and can demonstrate the capability sought by the Government. Vendors are asked to prove the technical applicability and user functionality of their solutions to fill the Government need based on the outcome of the challenges. The overall challenge itself is typically compromised of one or more events that exercise various aspects of a solution, such as an Interfaces, Usability and Security.

In this example, the Government used an Interface Challenge to perform a Technical Assessment of the

vendor's ability to successfully integrate their solution into a Government's virtual test environment, and demonstrate their technical ability to integrate and perform necessary functionality based on the criteria established by the government. The Government then conducted a Usability Challenge focused on evaluating a User Assessment of a vendor's ability to demonstrate their solution in the Government's virtual test environment while proving operational capability through user driven scenario based execution. The intent of the Usability Challenge is to determine if the solution is functionally relevant, performs efficiently and is aesthetically appropriate from a user perspective based on predetermined user scenarios. Finally, the Government also conducted an Operational Security Challenge to perform an Information Assurance (IA) Assessment of the vendor's ability to integrate their solution into the Government's operational test environment and prove compliance with the Government policy and security requirements. The use of commercial cloud services and formal usability testing methods (e.g. Morae and standard surveys) were used to capture user experience. The results from all events are being used to evaluate and select the capabilities and how to use them.

Hiring Qualified Employees: The following example highlights MITRE's Cyber Capture the Flag (CTF) competition [15], a corporate initiative aimed at adopting new approaches for seeking and evaluating high quality candidates, conducting interviews and hiring to build corporate talent pipelines.

The world today is hypersensitive to cyber security issues and as such employers are seeking expertise to help meet the demands on protecting their corporate assets. Finding high quality candidates for a cyber talent "pipeline" can be a challenge. Many potential employees claim to have knowledge relating to this field, made apparent by the abundance of certification acronyms present on many resumes. In order to better assess this field of applicants, it is believed that the interview process can be streamlined through the process of gamification, whereby applicants are asked to prove their technical abilities by competing in a hands-on capture-the-flag (CTF) style competition.

Using gamification as a hands-on interview will enable potential employers, especially within MITRE, to quickly identify top talent in the field of cyber security, allowing the corporation to maintain its high standards for hiring. The CTF is an annual nationwide cyber competition for high school and college students, where teams compete to solve realistic cyber problems in order to gain ranking in the game. Student performance is measured throughout the game and used as part of the evaluation process. Top teams and students win scholarships, training and intern job offers. The use of this system to hire talented, knowledgeable employees would greatly increase the Assured Computing core competency area of the organization.

5. RETROSPECTIVE

In this section, we briefly discuss our assessment of potential benefits and challenges associated with utilizing competitions and challenge events in the work environment.

As discussed previously in [2], there are numerous challenges to innovation, related to idea generation and solution development, sponsorships and funding, scalability, customer outreach, competition and timeliness.

To address these innovation challenges, competitions and challenges are one tool that federal agencies are using to drive innovation and solve mission-centric problems whether technical, scientific, or creative. As discussed in [12], some of the potential benefits include:

- Establishing an important goal without having to choose the approach or the team that is most likely to succeed;
- Paying only for results;
- Highlighting excellence in a particular domain of human endeavor to motivate, inspire, and guide others;
- Increasing the number and diversity of the individuals, organizations, and teams addressing a particular problem; or promote the challenge to national or international significance;
- Improving the skills of the participants in the competition;
- Stimulating the private sector investment that is many times greater than the cash value of the prize;
- Furthering a federal agency's mission by attracting more interest and attention to a defined program, activity, or issue of concern; and
- Capturing the public's imagination and perception of what is possible.

We have seen our customers take the plunge into challenge-based procurement. In some cases such as TALOS, it makes a lot of sense since the general concept of the procurement is so complex and the solution space is widespread. Here, the ability to tap into the collective knowledge and experience of industry and academia in the form of technically compartmented challenges helps to displace the lack of information that may exist on the programmatic side. Other customers have found ChBA processes to be more complex than expected. More traditional programs of record have attempted ChBA, only to revert back to more traditional approaches due to limitations and concerns expressed by their contracting and legal departments.

In some cases a happy medium was found by maintaining the traditional approach to the procurement solicitation process, while injecting key aspects of ChBA. In these cases, challenge problems were introduced and conducted as part of the overall solicitation proceedings.

We have found that there is no "best approach" to ChBA. Ultimately, the correct course of action will be dictated by the program/project in question. It's tolerance to technical scrutiny will have to be weighed against its need for innovative solutions.

6. CONCLUSIONS

This paper presents an examination of several approaches to foster open innovation through challenges and competitions in support of key business operations in the workforce.

In particular, such approaches are appropriate for projects that can be characterized by one or more of the following properties:

- Rapid schedule demands or responding to an urgent requirement,
- Responds to incremental capability needs,
- Depends on emerging or uncertain technology,
- Seeks attention of non-traditional innovation sources,
- Expects a short product life cycle or rapid refresh rate,
- Requires simultaneous industry and Government solution discovery, or
- Wishes to pay only for results.

We have highlighted specific examples of their use in "real world" environments and provide an assessment of applicability, benefits and challenges for implementation in large organizations.

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Repeatable and Traceable Software Verification for 3D Coordinate Measuring Machines

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Abstract—Coordinate Measuring Machines use complex algorithms to compute geometric shapes based on 3-dimensional measuring points. National metrology institutes are committed to verify that the computed results are correct. We report on a project funded by the European Union which, beside other topics, develops criteria to assess the fitness for purpose of computational software in metrology used by coordinate measuring machines.

1. INTRODUCTION

Coordinate Measuring Machines (CMM) are used in different manufacturing industries to ensure high accuracy of manufactured products but also high accuracy of the production run itself. The research project TraCIM (*Traceability for Computational-Intensive Metrology*), funded by the European Union, aims for the development of a coherent framework to ensuring traceability in computationally-intensive metrology, a basis for ensuring the trustworthiness and fitness for purpose of metrology software for coming decades.

We first introduce CMMs (Coordinate Measuring Machines) and report on the current manual process to verify correct and high precision measuring processes of such machines. We then describe the architecture and functionality of a system which automates the verification process.

2. COORDINATE MEASURING MACHINES

CMM are devices for measuring physical geometrical characteristics of different kind of objects. Maximal permissable error is typically around 1 μ m. The high accuracy measuring can be achieved by optical, tactile or even computer tomography scanner based capturing of probes. CMMs are hardened against floor induced vibration and are operated in an air conditioned environment to prevent measuring errors.

The capturing of probes differ from conventional measuring. Substitution points get captured and represented as x/y/z coordinates. Based on these substitution points the geometrical forms are computed. Figure 1 shows a circle and the captured substitution points in a plane.



Fig. 1. Substitution Points of a Circle

In practice, 3-dimensional geometric bodies such as cubes or cylinders have to be measured and their surfaces or volumes have to be computed. In modern manufacturing industry high accuracy measuring is important to verify that manufactured parts are within desinger-specified tolerances and to ensure that manufacturing processes stay in control during the production run.

CMM manufacturers therefore have to implement algorithms in some programming language to compute, for example, the circle (diameter, circumfence or circular area) depicted in figure 1 out of the substitution points. This can be done with different algorithms — for example least-square, Gaussian and Chebyshev algorithms — and, of course, different programming languages. For an introduction of CMM and used algorithms see [1], [2], [3].

3. MANUAL CERTIFICATION PROCESS

National Metrology Institutes (NMI) provide scientific and technical services for industry, science and society. For example, NMIs have to do some certification and support calibration of CMMs to support manufacturing processes of high technology industries.

At the moment the process of certification is done manually — probably by all NMIs around the world. NMIs own test data sets, which represent substitution points as introduced in section 2. The test data is sent per e-mail or ground mail (CD/DVD) to the requesting CMM manufacturer. The manufacturer uses the data as input for his metrology algorithms and sents the cumputed result back to the NMI, also per e-mail or ground mail. The NMI compares the computed result with the expected result and hands over a certificate if the computed and expected results match within some tolerances.

This manual certification process is lenghty, error prone and expensive because of the big portion of human work. Process automation is therefor an evident demand. However, there exist many more requirements, for example concerning traceability.

4. PROCESS AUTOMATION

Despite long history in formal verification research [4] only very small and simple software systems can be verified correct based on formal methods of mathematics. In practice the only valid choice to get some confidence in proper software operation is testing. Some NMIs own test data sets with corresponding test solutions. Some NMIs generate test data sets on the fly and the test solutions are computed, too.

The TraCIM Software Verification System (TraCIM SVS) which is under active development at the moment is part of the TraCIM project (Traceability for computational-intensive metrology). We depict the project further in section 5. A detailed description is also available online [5].

From a software engineering point of view the requirements for TraCIM SVS are quite standard:

- Clients, humans or other software systems ask for some (test) data
- After the data is received some computation regarding the computational coordinate metrology algorithms from section 2 takes place
- The resulting new data (the test result) is send back to the system as the solution for the test data
- After verification of the submitted data there is some kind of result, either success or failure

One of the most popular environments to implement such systems is the Java Platform Enterprise Edition (Java EE) [6]. TraCIM SVS is build with Java EE 7, the most current version. Java EE includes different parts, for example JavaServer Faces (JSF) to build HTML and Web based UIs, Enterprise JavaBeans (EJB) to implement business logic, Java Persistence API (JPA) to persist data to relational databases, JAX-RS to offer REST-like APIs and Context and Dependency Injection (CDI) to glue all the parts together.

The most important technical requirement of TraCIM SVS is the ability to handle all kind of tests, not only the 3D coordinate measurements features described in section 2. Therefore, TraCIM SVS consists of a core system and an innovative extension mechanism illustrated in the next section.

A. Architecture and Base Functionality

Figure 2 represents the main components of TraCIM SVS together with the client applications built by the CMM manufacturer. The TraCIM Server core offers REST based services and is hosted by a NMI. Functionality and communication steps are as follows

- 1) The client has payed the invoice and received some key, which enables him to request for test data. The key encodes also the type of test.
- 2) The client request TraCIM SVS for test data.
- 3) Because the request includes the key generated in step 1, TraCIM SVS is capable to identify the requested expert module. This special expert module is called and returns the test data.
- 4) TraCIM SVS sends back the test data as HTTP response.
- 5) The client computes the result for the received test data and sends the result back to the TraCIM SVS per HTTP request.
- 6) TraCIM SVS calls the expert module to compare the expected result for the provided test data and the actual result from the client. This comparison

can succeed or fail. In both cases the result of the method call is returned to TraCIM SVS and includes a certificate in PDF in case of success.

7) TraCIM SVS returns the comparison result to the client. TraCIM envelopes the expert extension generated PDF with some administration information from the involved NMI.

As depicted in figure 2 the server stores management information in a database. The kind of management information ranges from CMM manufacturer identification, payment information and the number of remaining tests to memorandums which test data set was delivered to which client, including the time of test data delivery and the time of result submission of the client.

As mentioned earlier expert extension can generate test data on the fly but can also manage a set of static test data and expected test results stored in a database. This optional database usage is also depicted in figure 2. TraCIM SVS does not restrict in any case the inner working of expert extensions.

B. Implementation and Used Technologies

Java EE is a well known technology in the area of big application implementation and in widespread use. Java EE is an umbrella specification and consists of about 30 single specifications, depending on the version used. Our project started with version 6 of Java EE. At the moment we migrate to Java EE 7. Java EE implementations manifest themselves in so called application servers. There are many companies which offer such application servers, for example WebLogic[®] from Oracle, WebSphere[®] from IBM and JBoss-AS/WildFly from JBoss. We use JBoss-AS — which was renamed to WildFly in the last version — because JBoss-AS is a so called open source implementation of Java EE. Therefore, there are no costs of purchase as well as no annual subscription costs. If in later project stages some demand for commercial assistance will arise, Red Hat the parent company of JBoss offers a commercial licence called EAP which can be subscribed to.

TraCIM server core and expert extensions are implemented as Java EE applications. Because the server core has a JSF based UI it is deployed as a WAR (Web Archive). The expert extensions are deployed as JARs (Java Archive). Both, server as well as expert extensions use some common set of classes. To prevent code redundancy a so called extension base is the third kind of Java EE application we use and is also deployed as a JAR.

The Java EE standard dictates absolute separation of different applications to prevent negative impact from one application to another in case of malfunction. In our case we have the demand that some application modules use some other modules which is not an uncommon requirement in big applications. All application servers offer some kind of non standard mechanism to allow modules to access modules from different applications. This mechanism is usually based on Java's classloader architecture. In TraCIM SVS classes from the extension base are used by the server as well as by the expert extensions. The expert extensions are additionally used by the server.



Fig. 2. TraCIM Architecture

Finally, TraCIM SVS consists of

- the extension base
- the server core
- one or more expert extensions

If a CMM manufacturer wants his software and in turn the complete CMM to get certified, he has to pay the mandatory fee for responsibilities of public administration and get the authorization to get test data sets and submit in turn test results for these data sets.

This is done by REST requests (REpresentational State Transfer), the most up-to-date interpretation of web services. The details about the communication steps are already described in section 4-A.

The most innovative aspect of the system architecture is based on the extension mechnism for expert extensions which is similar to plug-in architectures. If a new expert extension is implemented and has to be integrated into the system, no code change has to be accomplished. This is possible because auf Java's concept of a *service loader* which was introduced in Java 6 and manifests itself in the class ServiceLoader [7]. The mechanism is based on a simple convention which results in a self publication of classes implementing a particular interface. The class ServiceLoader can then be asked for all known implementation of the particular interface.

C. Future Enhancements

Because we describe here a some work in progress there will be of course some future enhancements. At the moment we are working on a design enhancement to allow expert extensions to run as separate server services. If, for example, some NMI X hosts the TraCIM server core but the expert extension runs on behalf of NMI Y on a different server, probably in a different country the collaboration of TraCIM server core and expert extensions has to be revised to reflect this requirement. The generated certificat has also to reflect this separation of responsibilities. It has to contain a functional part of the NMI offering the expert extension but also a more administration part of the NMI hosting the TraCIM server core which reflects the contractual relationship between the NMI and the CMM manufacturer. This point directly passes over to some legal aspects.

D. Legal Aspects

As the title of this paper suggests, the performed tests and certifications habe to be repeatable and traceable. Repeatable means that if a CMM manufacturer has requested a particular kind of test and has succeeded this test a consumer of the CMM can ask many years later for a further test. It has to be guaranteed that the consumer will get the same test data set as the manufacturer many years before to ensure that the outcome of the same submitted test results are the same.

Based on the same rationals and the responsibilities of public administration all test processes and test results have to be stored for decades to establish a complete chain of evidence if some disaster happend because of some earlier certification of wrong or even right test results.

5. PROJECT AND PROJECT PARTNERS

The European Cummunity has established the research project *Traceability for Computationally-Intensive Metrology* (TraCIM) which - beside other topics - develops criteria to assess the fitness for purpose of computational software in metrology and to verify them. The TraCIM home page [5] details objectives of this research project. The project started in 2013 and will be finished in 2015.

The national metrology institutes of the United Kingdom, Czech Republic, Italy, Germany, Slovenia and Netherlands as well as 4 CMM manufactures and 3 Universities belong to the project consortium.

Ostfalia, University of Applied Sciences, located in Germany is responsible for implementing the project supporting software and therefore TraCIM SVS. Close collaboration takes place with PTB, the NMI of Germany.

Some NMIs are working on different expert extensions at the time to complete the bunch of possible test data sets for different aspects of CMM characteristics.

6. CONCLUSION

We reported on the software system TraCIM SVS which main task is to support national metrology institutes to proof and certify the correct working of CMM. CMM are an important part of manufacturing processes in modern industry.

Workshops in fall 2013 and spring 2014 with the CMM manufacturers of the TraCIM project demonstrated the capacity of the design and implementation path we have chosen. At the moment one manufacturer is on the way to get his software certified from PTB, the German NMI, in a fully automatized process based on TraCIM SVS.

ACKNOWLEDGMENT

This research was undertaken within the EMRP project NEW06-REG3 TraCIM. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

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A Crossbar Switch Circuit Design

for Reconfigurable Wave-Pipelined Circuits

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ABSTRACT

This paper states crossbar switches which are used for the efficient design in reconfigurable wave-pipelined circuits. In the hardware- and host-based IPS (Intrusion Prevention System) which is used in mobile computing, reconfigurable circuits for intrusion detecting are implemented and their design requires techniques for highspeed and low-power operations. Wave-pipeline is a technique for realizing them. On the other hand, using it makes a problem that consumes a large amount of logic block in a conventional FPGA (Field-Programmable Gate Array). To solve this problem, the authors have developed a logic block for wave-pipelining. However, a crossbar switch for controlling the logic blocks to be used has not been developed. In this paper, the crossbar switches are developed in RTL (Register Transfer Level) and delay times, area and power are calculated.

Keywords: Crossbar Switch, FPGA, Wave-Pipeline, IPS, Reconfigurable Circuit.

1. INTRODUCTION

Today, smartphones or tablets are used very well all over the world. They can be connected to high-speed Internet in a variety of locations through wireless LAN or high-speed mobile communications, such as LTE (Long Term Evolution). While the convenience of Internet access can be improved, the solution of problems of information leakages, computer viruses and unauthorized computer accesses is made difficult further more.

The purpose of preventing and detecting such problems, an IPS (Intrusion Prevention System) and an IDS (Intrusion Prevention System) can be used. Conventional IPS and IDS are classified into network-based and host-based depend on place where the system is set up and have following problems [1].

In the case of using a Host-based IPS (HIPS) or a Hostbased IDS (HIDS), they consume CPU power and electric power of buttery by detection processing and are not able to execute a detailed analysis at the packet level that CPU load is demanded. In addition, they are not able to execute anomaly detection of high accuracy.

When a Network-based IPS (NIPS) or Network-based IDS (NIDS) is used, they are not able to detect unauthorized computer access that occurs between computers in LAN and are hard to process all the packet analyses with the increase of the amount of packet. And a high performance computer is needed for them and expensive. In addition, installation of the IPS or the IDS on a smartphone or a tablet is difficult. The CPU of them operates more low-speed than PC and ultra-low-power consumption.

For solving these problems, the authors have developed H-HIPS (Hardware-based HIPS) [2]. The IPS need a reconfigurable device for processing of intrusion detection executes in IDL (Intrusion Detection Logic). When a custom design VLSI processor is used, specific protocols and new functions cannot be added to it as a circuit for intrusion detection processing. Therefore, it cannot be used for IDL.

The reconfigurable device has the weak point in the viewpoint of the speed and power consumption compared with a custom-made LSI. It is necessary to cover the weak point by the design method. There is wave-pipeline technique [3]-[5] in one of the design methods. The technique can be used in an FPGA (Field Programmable Gate Array) to be used very well as a reconfigurable device [6].

On the other hand, the FPGA is not considered wavepipelined designs. Because wave-pipeline technique makes pipeline operations by a timing adjustment, a large amount of buffer is needed for the timing adjustment. In other words, it consumes a large amount of logic block in the FPGA. To solve this problem, we have developed the logic blocks for wave-pipelining [7]. However, a crossbar switch and routing to connect between the logic blocks is not developed.

In this paper, two crossbar switches are developed using 0.18 um CMOS technology for reconfigurable wavepipelined circuits. One is a crossbar switch of a simple configuration and the other can change the position of the wiring to cross. These switches are developed using VHDL. That is, automatic generation of an FPGA is possible.

This paper is organized as follows. Section 2 presents the outlines of reconfigurable wave-pipelined circuits. In Section 3, two crossbar switches are developed. Then, delay times, area and power are calculated in Section 4. In Section 5, the conclusions are made.

2. RECONFIGURABLE WAVE-PIPELINED CIRCUITS

Wave-pipeline technique is a design technique for the purpose of low-power and high-speed operations. For this design technique can be implemented at the gate level, reconfigurable wave-pipelined circuits can be designed on an FPGA. Fig. 1 shows outlines of pipeline techniques. Fig. 1(a) is conventional pipeline and Fig. 1(b) is wave-pipeline.

In conventional pipeline, pipeline registers are required for pipeline operations. The use of pipeline registers is responsible for the increase in power consumption. Further, the clock frequency is dependent on the delay time of the critical path. Meanwhile, wave-pipeline is capable of pipeline operation without the pipeline registers by adjusting the minimum delay time and maximum delay time.



Fig. 1. Pipeline Techniques (a) Conventional Pipeline (b) Wave-Pipeline



Fig. 2. 4-bit Adder



Fig. 3. 4-bit Wave-Pipelined Adder

Fig. 2 shows the 4-bit adder. It is designed with logic blocks used by an FPGA. Then, the 4-bit wave-pipelined adder is designed using the logic blocks based on the circuit of Fig. 2 and shown in Fig. 3. The gray areas in Fig. 3 are logic blocks inserted for timing adjustment. The area of the logic block is larger than that of a buffer. Therefore, the authors have developed a logic block for timing adjustment in [7]. When we use the logic blocks for wave-pipelining, the area reduces to 28.5%.

3. RTL DESIGN OF CROSSBAR SWITCHES

In this section, the authors develop two crossbar switch for efficient reconfigurable wave-pipelined circuits. Design environments of table 1 are used for these design. First, the authors design the selector shown in Fig. 4. Then, crossbar switch of a simple structure (CSSS) is designed and shown in Fig. 5. The crossbar switch is for the selection of column or row.

The feature of the crossbar switch is a simple structure. However, Selection of rows and columns of any is impossible. In order to solve this problem, the authors design the crossbar switch for any line selections (CSALS). Fig. 6 shows the CSALS.

OS	Cent OS 5.9 x86
СРИ	Intel Core 2 Duo E6600 (2.4GHz)
Memory	2 GBytes
Logic synthesis	Synopsys Design Compiler H- 2013.03-SP2
Technology	Rohm 180 nm C-MOS
Standard cell	Tamaru/Onodera Lab. of Kyoto
library	Univ. [8]

Table 1. Design Environments









Fig. 7 Circuit of Fig. 4

Fig. 5 Crossbar Switch of a Simple Structure.



Fig. 6. Crossbar Switch for Any Line Selections



Fig. 8 Circuit of Fig. 5

The authors execute logic synthesis of the VHDL sources in Fig.4, Fig. 5 and Fig. 6 by using Design Compiler of Synopsys Inc. These results are shown in Fig. 7, Fig. 8 and Fig. 9.



Fig. 9 Circuit of Fig. 6

Table 2. Delay times, Area and Power

	Minimum Delay	Maximum Delay	Area	Dynamic Power	Leakage Power
Selector	0.2351 ns	0.2676 ns	25.8 um ²	4.5548 uW	44.2698 pW
Fig. 8	0.2351 ns	0.2676 ns	103.2 um ²	18.0758 uW	177.0792 pW
Fig. 9	0.2438 ns	2.1588 ns	412.9 um ²	98.5787 uW	708.3168 pW

4. DELAY TIMES, AREA AND POWER

In this section, delay times, area and power of the crossbar switches are calculated using Design Compiler. These results is shown in Table 2. Regarding the delay times, it has become clear that the delay times of Fig. 9 is less than the delay time of the logic blocks. Further, the delay time of the logic blocks, the following equation is satisfied.

$$D_{MIN} \le D_{LB} \le D_{MAX} \tag{1}$$

Here,

 D_{MAX} : Maximum delay time of Fig. 9,

 D_{MIN} : Minimum delay time of Fig. 9 and

 D_{LB} : Delay time of logic blocks.

That is, the circuit of Fig. 9 can be used for delay time adjustment by adjusting the path of the crossbar switch.

In the results of area, the area of Fig. 8 is less than that of the logic blocks. The area of Fig. 9 is also less than that of conventional logic block. Thus, the use of Fig. 9 contributes to the resource reduction in reconfigurable wave-pipelined circuits.

5. CONCLUSIONS

Wave-pipeline technique on reconfigurable circuits made the problem that consumes a large amount of logic block in a conventional FPGA. In this paper, the authors have developed and evaluated two crossbar switches. One is a crossbar switch of a simple configuration and the other can change the position of the wiring to cross. And, delay times, area and power were calculated in the CAD. According to the results, these switches are available for reconfigurable wave-pipelined circuits. In addition, CSALS is effective in the timing adjustment of wave-pipelined circuits.

The future works are the development of optimization techniques of timing adjustment for reconfigurable wavepipelined circuits utilizing the reconfigurable features.

ACKNOWLEDGMENT

This work has been supported in part by VLSI Design and Education Center (VDEC), the University of Tokyo in collaboration with Synopsys, Inc. and KAKENHI Grant Numbers 25330149. The standard cell library used on this research was developed by Tamaru/Onodera Lab. of Kyoto Univ. and released by Prof. Kobayashi of Kyoto Inst. of Tech.

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Six Sigma Black Belt Roles & Selection Criteria: Comparing Literature and Practitioners' Views

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ABSTRACT

The purpose of this study was to identify the most appropriate roles that Six Sigma Black Belts should hold in an organisation and the corresponding skills and characteristics (selection criteria) that they should acquire, in order to be considered as desired candidates. After the review of the existing literature, a survey questionnaire was designed to capture the practitioners' point of view. Results from 105 participants from around the world were analysed to draw comparisons between the literature and the practitioners' viewpoint. The comparison between literature and practitioners' perception shows that even if the roles and the responsibilities coincide in some level, significant differences can be noticed for the skills and characteristics that Black Belts should possess.

Keywords: Six Sigma, Black Belts, Roles, Responsibilities, Skills, Characteristics, Empirical study

1. INTRODUCTION

Six Sigma is a project – driven management approach [1] which strives to reduce variability on products/ services and processes by finding, controlling and eliminating the root causes of variation [2]. The method was introduced for the very first time by Motorola in 1987 [1][3], when Japanese companies started competing in the electronics industry [4]. Since then, many other companies have adopted the methodology, such as: Allied Signal, General Electric, Texas Instruments, Honeywell, Sony, Caterpillar, Johnson Controls, Citibank and others [2][3][5][6].

Antony and Banuelas [7] approach the methodology from two different viewpoints: i) the business and ii) the statistical point of view.

i. Business Viewpoint

From a business perspective, a more holistic view of the methodology within the organization is suggested. As Antony and Banuelas [6] explain, in business terms Six Sigma can be viewed as a "business improvement strategy used to improve profitability, to drive out waste, to reduce quality costs and improve the effectiveness and efficiency of all operations or processes that meet or exceed customers' needs and expectations".

ii. Statistical Viewpoint

Sigma (greek: σ) is the Greek alphabet letter used in statistics to describe variability. As McAdam and Lafferty [8] state: "... a sigma quality level offers an indicator of how often defects are likely to occur in a process". Six Sigma, from a statistics point of view, implies having less than 3.4 defects per million opportunities (DPMO) or, in other words, a success rate of 99.9997% [4][6][9]. However, not every single process in an organization should operate in a six sigma level. According to Linderman et al. [4], the methodology should be applied only to the strategic critical processes and those where the benefit could overcome the implementation cost.

Six Sigma was implemented first in manufacturing operations, as happened with all the other Quality Management (QM) approaches. When organizations realized the benefits of applying this method, Six Sigma started to be deployed in various functional areas, such as: marketing, engineering, purchasing, servicing, and administrative support. Even if many organizations have achieved great savings and have improved their processes through Six Sigma, some authors criticise the approach as being similar to previous concepts [10].

In order for a Six Sigma project to be implemented, organizations need to form project teams composed of employees who have received training in the concept. The team members are divided into levels, according to their in-depth knowledge and experience, developing a hierarchy, called "Belt Hierarchy". This hierarchy usually consists of: Yellow Belt, Green Belt, Black Belt, Master Black Belt and Six Sigma Champion [11].

According to the literature, Black Belts (BBs) are usually fulltime practitioners who have been selected and trained in order to be able to effectively apply six sigma statistical tools and techniques [12][13], responsible for some of the most important projects in organisations that deploy the Six Sigma methodology. However, no scientific research has been conducted to identify the exact skills and characteristics that these practitioners should acquire, in order to be considered as ideal candidates for such a working position. In this paper, an overview of the literature on the Black Belt skills and responsibilities is going to be presented. Also, the results from the first global empirical study to identify the Black Belt selection criteria will be shown. Finally, comparisons between the academics' and practitioners' point of view will be drawn.

2. LITERATURE REVIEW

In this part, the most commonly suggested Black Belt roles/ responsibilities, skills and characteristics which can be found in the literature are going to be presented.

Black Belt Roles and Characteristics

The literature related to the Black Belts' roles and responsibilities is limited. In an effort to collect the existing published papers on the topic, the researchers came across 9 articles. In these articles, 31 different roles related to a Black Belt job position are mentioned. The table below (Table 1) shows the top roles/ responsibilities found in the literature.

Table 1. Top Black Belt Roles/ Responsibilities in Literatur
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Roles/ Responsibilities	Author	Freq.
Team Leader	[14][15][16][17][18] [19][20]	7
Full-time resource for executing projects	[14][16][18][20][21] [22]	6
Mentor	[16][17][19][21]	4
Change agent	[16][18][19]	3
Applies statistical tools	[14][19]	2
Coach	[18][21]	2
Involved in improvement projects	[16][20]	2
Teacher	[16][21]	2
Trainer	[17][18]	2

Twenty two more roles were suggested by just one author. The list includes roles such as: "Critical problem solver", "Strategic impact processes leader", "Investigates root causes", "Identifies business opportunities", "Improves process efficiency by reducing waste".

Black Belt Skills

As happens with the BB roles, the literature related to the Black Belt skills is extremely limited. Considering the Black Belt roles as presented above, we should expect that they should possess a mixture of "hard" and "soft skills".

A total of 34 skills have been suggested by 7 authors. The skills that top the rank are shown in Table 2.

Table 2. Top Black Belt Skills in Literature

Skills	Author	Freq.
Leadership skills	[2][14][17][18][22] [23]	6
Analytical skills	[22][23][24]	3
Technical skills	[14] [17][23]	3
Collaboration skills	[18][23]	2
Organisational effectiveness	[14][17]	2
Process oriented	[18][23]	2
Project Leadership	[2][22]	2
Social/ Interpersonal skills	[23][24]	2
Training skills	[14][18]	2

The analysis highlights an interesting finding. Out of the nine most suggested skills that a Black Belt should possess, eight are considered as "soft skills" (or the soft aspect of these skills is considered paramount). The "hard skill" that is appreciated is the "Technical" suggested by three authors. Laker and Powell [25] define soft skills as "intrapersonal skills such as one's ability to manage oneself as well as interpersonal skills such as how one handles one's interactions with others", while hard skills as "technical skills that involve working with equipment, data, software, etc.".

Other skills ranked lower in the list are: "Knowledge of Lean", "Management skills", "Team building skills", "Systems Thinking knowledge" and other.

Black Belt Characteristics

In this section the essential characteristics that a desired Six Sigma Black Belt should possess will be discussed, but first of all, distinction between skills and characteristics should be made.

According to Collins Dictionary [26], a skill is "something, especially a trade or technique, requiring special training or manual proficiency", while a characteristic is defined as "a distinguishing quality, attribute or trait". Further search was made and the definitions stated by The American Heritage Dictionary [27] are provided. The American Heritage Dictionary [27] defines skills as "Proficiency, facility or dexterity that is acquired or developed through training or experience". As for the characteristics, it claims that they are "Features that help to identify, tell apart or describe recognizably; a distinguishing mark or trait". From the definitions given can be concluded that skills are trades that can be taught and the individuals can prove their proficiency by applying techniques, for example in the workplace. Characteristics, on the other hand, are mostly inherited qualities and traits that can tell apart individuals. Finally, it should be mentioned that there are some traits that fall in both categories. An example in case could be leadership.

Trying to identify the ideal candidate to fill a Black Belt position or to be trained as a Black Belt, six publications have been traced. Even if not many papers and books can be found, as it happens in regards to BB roles and the skills, the research which has been made was much more structured.

More than 40 Black Belt characteristics are mentioned in the relevant literature. In Table 3 the Black Belt characteristics mentioned most frequently are presented.

Table 3. Top Black Belt Characteristics in Literature

Characteristics	Authors	Freq.
Results-oriented	[20][22][28][29]	4
Change agent	[20][22][29]	3
Team builder	[20][22][28]	3
Allows room for (Anticipates)	[28][29]	2
failures/mistakes		2
Customer-advocated	[20][22]	2
Innovative	[20][22]	2
Inspires others	[28][29]	2
Leader	[14][30]	2
Motivated to lead	[20][22]	2
Positive mindset	[20][30]	2

According to Table 3, the three attributes which seem to be the most frequently identified in order for somebody to be selected as a Black Belt are: "Result-oriented", "Change agent" and "Team builder". Some of the least suggested characteristics traced are: "Technical aptitude", "Open minded", "Persistent", "Initiative", "Effective communicator", "Analytical thinker" and other.

3. RESEARCH METHOD

In order to identify the roles that a Black Belt should hold in a company and the skills and characteristics that they should acquire, a survey questionnaire was designed. As the aim of this study was to explore the practitioners' views on Six Sigma Black Belts' related matters, the targeted participants for the conducted survey were primarily Six Sigma practitioners at the levels of Black Belt and Master Black Belt. Furthermore, Six Sigma Champions were taken into consideration, as they work closely with Black Belts, supervising their progress and supporting them in overcoming obstacles [31]. Finally, a fourth category of respondents were considered. This consisted of Quality Management Professors and Operations Excellence Managers who are considered to be experts in the field.

A number of 153 answered questionnaires were returned of which 105 are considered usable for this research. Table 4 presents the respondent's profile.

Table 4. Respondents' Profile

	Champion	MBB	BB	Other
Years of				
Experience:				
<1-2		3	19	3
3-5		1	26	2
>5	5	17	19	10
Industry:				
Manufacturing	4	9	28	8
Service	1	12	36	7
Size of the				
company:				
Small/ Medium		3	2	3
(<50 emp.)				
Large (>51 emp.)	5	18	62	12
Sum	5	21	64	15

As the researchers' intention was to get a global perspective, practitioners from different countries were contacted to participate in this study. Responses were received from practitioners operating in 14 different countries. These countries are presented in Table 5.

Table 5. Respondents Location	T	able	5.	Respon	ndents'	Location
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Location	No of	Location	No of
	resp.		resp.
Brazil	4	Netherlands	3
India	42	Pakistan	1
Ireland	1	Singapore	6
Italy	2	Sweden	2
Korea	2	UAE	1
Malaysia	1	UK	32
Mexico	1	USA	7

4. RESULTS

Black Belt Roles/ Responsibilities

Respondents were asked to choose up to 10 roles and responsibilities - from a list of 30 that the literature suggests as the most appropriate - which they think that best represent a Black Belt's position.

Table 6 presents the top 10 roles as extracted after the analysis on the participants' response.

Table 6. Top 10 Black Belt Roles/ Responsibilities

Rank	Role	Freq.
1	Change agent	60
2	Applies statistical tools	53
3	Coach	50
4	Critical problem solver	48
5	Analyses root causes	46
6	Mentor	45
7	Leads strategic projects	42
8	Demonstrating bottom-line results into	38
	hard cash savings	
9	Involved in improvement projects	38
10	Project manager/Leader	38
11	Six Sigma expert	38
Datas in		:

Roles in position 8,9,10 and 11 have same frequencies

Some of the least recommended roles/ responsibilities, from the practitioners' point of view, are those of: "Coaching business leaders", "Being involved in decision making" and "Being assigned temporary assignments".

It has to be highlighted that no significant differences among the Black Belts' and Master Black Belts' responses were noticed, especially in the top 5 positions of this list. Also, according to the analysis, Black Belts are expected to hold the same roles in Manufacturing and Service Industry as 7 out of the 11 roles were found to match.

Black Belt Skills

Analysis pertaining to the skills that a Six Sigma Black Belt should acquire in order to be considered as a desired candidate was also conducted. The analysis which was performed is similar to that of the Black Belt roles/ responsibilities, as presented above.

The top 10 skills that a BB should acquire are listed in Table 7.

Table 7. Top 10 Black Belt Skills

Rank	Skills	Frequency of Occurrence
1	Analytical skills	84
2	Expertise in Six Sigma methods/ tools	75
3	Data/ Fact driven	62
4	Coaching skills	56
5	Problem solving skills	56
6	Leadership skills	42
7	Presentation skills	37
8	Customer advocate	36
9	Project Management skills	36
10	Results-oriented leadership	36

Interestingly enough, the results show that seven out of the top ten skills can be considered as soft skills or the soft element is principal on them. These are: i) Analytical skills, ii) Coaching skills, iii) Problem solving skills, iv) Leadership skills, v) Presentation skills, vi) Customer advocate and vii) Project management skills.

Similarities can be noticed between Master Black Belts' and Black Belts' views in the top five positions. However, for the rest of the rank differences appear, with MBBs ranking in high positions: project management and presentation skills, result oriented leadership, management, problem solving skills and systems thinking knowledge. On the other hand, BBs rank higher: knowledge of Lean, listening and mentoring skills and customer advocacy.

Since many "soft skill" were found to be important in the literature, researchers felt the need to identify whether "soft skills" are needed along with "hard skills" for a successful Black Belt career. According to the results, 104 out of 105 respondents consider "soft skills" as vital assets that a Black Belt needed to acquire, suggesting a balanced analogy of "hard" and "soft skills", with 50.3% for "hard skills" and 49.7% for "soft skills".

Black Belt Characteristics

Practitioners were asked once again, to choose up to ten characteristics that they perceive as the most critical for a Black Belt position. The results are shown in Table 8.

Rank	Characteristic	Frequency
1	Ability to understand the "big picture"	71
2	Data-driven	65
3	Analytical thinker	59
4	Effective communicator	56
5	Problem-solving ability	56
6	Change agent	48
7	Results-oriented	35
8	Basic statistical knowledge	34
9	Process-oriented	34
10	Leader	31

Table 8. Black Belt Characteristics

As Table 8 presents, six out of ten characteristics can be considered as characteristics needed for interpersonal interaction. These are: i) "Ability to understand the big picture", ii) "Analytical thinker", iii) "Effective communicator", iv) "Problem-solving ability", v) "Change agent" and vi) "Being a Leader". The other four characteristics are: i) "Data-driven", ii) "Result-oriented", iii) "Knowledge of basic statistics" and iv) "Being process-oriented".

As the characteristics required for the Six Sigma Black Belt practitioners might be influenced by cultural factors, analysis was conducted in order to find out whether Eastern and Western countries practitioners share the same views about which characteristics are the most important to be acquired by BBs. It is notable that no significant differences can be viewed between practitioners' from Western and Eastern countries.

5. DISCUSSION

In the paper, the most appropriate roles/ responsibilities and the selection criteria (skills and characteristics) according to the existing literature and the practitioners' views were presented. A comparison between those extracted from the literature and the survey questionnaire used for this study could show effectively whether academics and practitioners share the same views. Table 9, 10 and 11 present the comparison between the roles/ responsibilities, skills and characteristics extracted from the literature and the survey instrument in descending order of frequency occurrence. The items which were found different between literature and practitioners are in bold.

Table 9. Black Belt Roles/ Responsibilities:	Comparison
between Literature and Practitioners'	Views

Roles/ Responsibilities			
	Literature	Practitioners	
1	Team Leader	Change agent	
2	Full-time resource for executing projects	Applies statistical tools	
3	Mentor	Coach	
4	Change agent	Critical problem solver	
5	Applies statistical tools	Analyses root causes	
6	Coach	Mentor	
7	Involved in improvement projects	Leads strategic projects	
8	Teacher	Demonstrating bottom-line results into hard cash savings	
9	Trainer	Involved in improvement projects	
10		Project Manager/Leader	
11		Six Sigma expert	

¹ Items in positions 11 indicate same frequencies

 Table 10. Black Belt Skills: Comparison between Literature and Practitioners' Views

Skills				
	Literature	Practitioners		
1	Leadership skills	Analytical skills		
2	Technical skills	Expertise in Six Sigma methods/ tools		
3	Analytical skills	Data/ Fact driven		
4	Organisational effectiveness	Coaching skills		
5	Training skills	Problem solving skills		
6	Project leadership	Leadership skills		
7	Process oriented	Presentation skills		
8	Social/Interpersonal skills	Customer advocate		
9	Team building skills	Project Management skills		
10	Collaboration	Results-oriented leadership		
11	Expertise in Six Sigma methods/			
	tools			

¹ Items in positions 11 indicate same frequencies

According to the tables (Tables 9, 10 and 11), many differences can be noticed. Starting with the roles/ responsibilities that were suggested, it can be argued that academics and practitioners have reached a level of agreement. Out of the 11 roles that are perceived as those that a Six Sigma Black Belt is expected to perform 6 are the same, expressing a kind of unanimity. However, when it comes to skills and responsibilities significant variance is presented.

Table 11. Black Belt Characteristics: Comparison between	
Literature and Practitioners' Views	

Characteristics		
	Literature	Practitioners
1	Results-oriented	Ability to understand the ''big picture''
2	Change agent	Data-driven
3	Team builder	Analytical thinker
4	Allows room for (Anticipates) failures/mistakes	Effective communicator
5	Customer-advocated	Problem-solving ability
6	Innovative	Change agent
7	Inspires others	Results-oriented
8	Leader	Basic statistical knowledge
9	Motivated to lead	Process-oriented
10	Positive mindset	Leader

As far as skills are concerned, only three out of ten match. These three are: "Leadership skills", "Analytical skills" and "Expertise in Six Sigma methods/ tools". According to the literature, "Leadership skills" come first, while practitioners place them in the sixth position. "Analytical skills" are placed in the third position according to the literature. On the other hand, practitioners consider them as the most important skills that a BB should acquire. Finally, expertise in Six Sigma methods/ tools appears in the eleventh place, when practitioners place them in the second position. Most of the different skills proposed from either literature or practitioners can be considered as soft skills, with the exception of "Technical skills" – traced in literature.

When it comes to compare the characteristics found in literature and the analysis of the practitioners' thoughts, the same conclusion as with the skills can be drawn. Out of the ten Black Belt characteristics, only three found to be commonly agreed. "Results-oriented" comes up as the top characteristic that a BB should acquire, according to the literature, while it appears in the seventh position for practitioners. Being a "Change agent" seems to be the second most important with "Leadership" in the eighth position. For the practitioners, "Change agent" comes sixth and leadership only tenth.

6. CONCLUSION

Only few sources can be traced in the literature related to the roles/ responsibilities that Six Sigma Black Belts perform and the skills and characteristics that they should acquire in order to be perceived as desired candidates for such a demanding position. However, no unanimity among the authors who propose them can be noticed. This study intended to compare the literature's and practitioners' point of view on the most essential skills and characteristics that Black Belts should acquire. A review of the current literature was conducted to identify the most mentioned roles/ responsibilities, skills and characteristics for a Black Belt. Consequently, the items extracted were used to construct a survey questionnaire and identify the practitioners' views. Results show that even if the literature and practitioners agree on the roles/ responsibilities performed by Black Belts, no consensus on the skills and characteristics has reached.

Overall, this study constitutes the most structured effort, in order to define the actual roles/ responsibilities that Black Belts perform in the real world and identify what skills and characteristics are needed, according to the practitioners' experience. Findings can be used by those responsible to select the most suitable candidate to train or to fill a Black Belt's position. However, it has to be noted that further research should be made, probably with bigger sample size. Also, semistructured interviews with practitioners should be conducted to get a more in-depth understanding.

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Transportation and Environment – Economic Research

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ABSTRACT

Externalities are a frequently discussed topic and as for transport they are mostly mentioned in the relation with the so-called harmonization of costs of particular means of transport. Although the problems of their internalization is very often mentioned and presented within the framework of transport policies (both national and European), in practise this problem remains unsolved. In this article I deal with the reasons why it is so. First it is the fact that the question of externalities is in fact a political question (same as deciding on public goods) where a conflict of particular participating persons or groups may play a big part. The other question is how to solve this problem. One possibility seems to be an introduction of the so-called purpose taxes whose profit is purposely bound onto financing a concrete public good or service. I deal with this problem as well. The economy of the environment studies economic consequences of human's activities on the environment and within economics it searches such a mechanism that would motivate production and consumption spheres for more considerate behaviour towards environment.

Keywords: transportation, tax, externalities, environment, transaction costs

1. INTRODUCTION

One of the problems areas, which the economics of the environment deals with, are the questions of external externalities of human activity, external costs and their internalization into costs of pollution. The problem of externalities in transport has more special characteristics as for example the question of public possessions, possibility of emergence of conflict of interest groups, considerable political and social function of transport etc. Many problems are general - for example the difficulties connected with monetary quantification of external costs or inter-disciplinarity of this problem (externalities can be hardly solved from the standpoint of contemporary knowledge of economics as it causes damages particularly in other fields of human's activities than transport itself – for example health care, living etc.) Externalities in transport are then investigated with the aim to internalize external costs into the cost of their originator. If we had to keep strictly the principle "User pays", the internalization of externalities would fundamentally impact most inhabitants (the increase would influence road transport - bus, individual and freight as well as railway transport, which is more considerate towards the environment but where a big problem is the capital demandingness of infrastructure and external costs due to its maintenance and face-lifting. If we consider that railway and road traffic is a source of employment for about 300 thousand inhabitants in the Czech Republic and that about 3 million people are users of individual car transport it will not be politically easy to put through an increase in prices in transport which would project into operation costs and further into tariff prices, fare or fuels regarding international competitiveness of the Czech Republic as well.

Then the aim of this internalization is the influence on the distribution of proportions of transport system or on the change of transportation shares that are currently displayed by two fundamental fields of the transport system of the Czech Republic – road and railway transport.

It is a question how a possible price adjustment can change this rate regarding the fact that it is the only one of factors that influences decision making of a passenger or transporter when choosing means of transport. At minimum we speak about the necessity to integrate the information on its influence on the environment and infrastructure into the price of transportation.

Still the question how to carry out this internalization remains and two sub-questions are derived from this:

• In which height the internalization should be carried out. Then the problem of externalities cannot be only narrowed on their finance quantification but it is also necessary to perceive their relations to political environment which decides on the internalization. Here undoubtedly the conflict of particular interests appears. Another problem is how the conflict of interests can influence the process of internalization of externalities, which is however more a case of political (or social) choice than economic question. Finally it depends on political representation whose representatives have to be observed from the standpoint of the theory of public choice as persons whose aim - as the aim of every economic unit – is to maximize their own benefit if it introduces such measures.

• By what kind of taxes to carry out the internalization, if the problem of consumer tax and its further distribution within the framework of national budget and the possibility to introduce the so-called purpose taxes (by the term purpose tax we understand such a tax, whose yield is expediently tied to financing a concrete public goods or services. It is such a kind of tax that carries information on the way of its further use in it) in transport seems to be topical. Transport infrastructure or public transport are considered public goods and are financed from public funds. However it is interesting to compare the properties of these goods with the properties by which the public goods are defined as standard ones.

Generally the externalities arise in case when the property rights are not properly qualified and exacted, in other words they appear at the moment when particular agents consume certain utility goods together without properly concluded agreements on price and quality when utility functions of a consumer and production functions of a producer are not influenced only by direct participants in production and consumption processes but also by other participants and factors of economic and social processes as expressed by these functions:

$$y_h = g_h(v_h, v_k) \tag{1}$$

$$x_l = f_l(u_l, u_k) \tag{2}$$

 $u_l \dots$ benefit of consumer l

 u_k ... influence of consumer *l* on its own benefit

 x_k ... influence of other participants on benefit of a consumer

 y_h ... output of producer h

- v_h ... influence of producer h on his own output
- v_k ... influence of other participants on producer's output

Basic division is on positive and negative externalities. Positive externalities are external economy, i.e. they increase production or benefit for such externalities which are influenced by the externality. Negative externalities on the contrary decrease benefit of the other part and mean negative external economy. As an example we can mention frequent forms of pollution of the environment. Externalities can be further sorted according to the way of their origin as pecuniary and technological. Pecuniary externalities arise due to mutual interaction of economic activities within national economy and work via changes of price relations and do not disturb allocation market function. Technological externalities, which arise through the mediation of specific features of concrete activities, are problematic. They do not work through price system while they spoil activities and production and utility functions of other subjects. Externalities are divided into partial (influencing limited number of subjects) and global (of the impact on big number of subjects) or into monodimensional (an externality works in the same field where it origins) and multi-dimensional ones. Generally we can say that externalities influencing the environment belong among multi-dimensional externalities.

From the point of view of the external costs solution two factors are important – the first one is unambiguously the delimitation of property rights, the second is the volume of

transaction costs connected with the proper solution. The necessary part of property rights is the option to treat our own property freely and the possibility to enforce the rights connected with the ownership. And transaction costs can be defined as costs of price system or costs connected with a change of property rights. The theory of transaction costs has been often neglected however it is of key importance to understand economic processes. We can say that if we proceeded on the unreal assumption of zero transaction costs, the market system would allocate sources with maximum efficiency. Regarding transaction costs many of them will not be carried out as in many cases the costs of searching for the counterparty of the change will be too high. [1]

2. EXTERNALITIES AND THEIR SOLUTION

The solution to external costs can be carried out in two ways. The first one is called market negotiations and it can be used when two conditions are met – clearly delimitated property rights and low transaction costs. The negotiation is then led with the goal to find such an extension of externalities when the sum of costs on prevention of external costs and cost on removing damages were at minimum which can be summarized by the following figure:



Fig. 1: Optimum level of pollution at the market solution to externalities

$$C_{G} = C_{A}(x) + C_{S}(x) = min!$$
 (3)

"If parties can negotiate and compensate each other, an effective solution can be found – i.e. optimum level of pollution. The externalities are only the consequence of unclear property rights and their insufficient protection" [1]

According to Fig. 1 and relation (3) the optimum height of pollution can be found at private negotiation. In case of high transaction costs and unclear owner relations such concept cannot work and classical economic theory uses the principle of the so-called Pigovian taxes. This principle assumes introduction of extra taxation which will be imposed on the originator of negative externalities or support for such offers who produce positive externalities or due to their activities they reduce negative externalities.

This principle has several drawbacks. The first is an unwillingness of governments to make such a step due to a decrease in competitiveness of economy. The second problem lies in the necessity of elastic demand and offer. This can be shown in the following graphs displaying the principle of Pigovian taxes. The third problem is the limited possibility of quantification of external costs from which the height of a tax or support could be derived. This principle can be shown on mutual interaction of the curve of demand (D), supply (S) and marginal external costs MC_{ext} or limiting external revenue MR_{ext} .

The assumption is that due to additional taxation T_{ext} the supply curve will move to the left that is to the position D', increase in price and the subsequent decrease in demand for given good will appear. The solution to externalities by supports or taxes was promoted by English economist Arthur C. Pigou. In spite of his liberal thinking in the area of externalities he agreed with irreplaceable role of a state. Pigou was a founder of the so-called Economics of Welfare while he defined the so-called Paret optimum for optimum allocation of resources. This happens when for at least one member of a society the allocation of resources causes improvement of his situation and simultaneously for no member it causes worsening. This can be attained only when the conditions of a complete competition are fulfilled.



Fig. 2: The principle of introducing the so-called Pigovian tax

The influence of supports can be shown in a similar way. The assumption is that this kind of support will result in higher supply of those goods, which produce positive externalities. The goal is to stimulate supply when decreasing the price from p_e to p_e' and to move demanded quantity from q_e to q_e' :



Fig. 3: Solution to externalities by means of allocation of grants

This concept may be problematic for two reasons. The first one is the non-elasticity of a demand but also supply function which is distinct in transport. In such case even a decisive taxation of an activity, which produces negative externality, does not have to lead towards important decrease in production in spite of a high increase in price (Fig. 4). As it was written above, the elasticity of demand at any good depends significantly on the existence of its appropriate substitutes. Replacement of road transport is very problematic regarding the quality parameters of other means of transport and current costs and other economic parameters. In an extreme case such internalization does not meet it purpose and only increases the costs of the users of road transport without any real effect on improving the features of the environment. Its negative consequence may be even decrease in competitiveness of national economy or imposition of the socalled excess burden of taxation.



Fig. 4: Insufficient effect of the taxation at non-elastic demand

The second drawback may be the decrease in utility of a supplier and demander, which can be displayed in the following figures for the balance in initial point E and further in point E', to which the market arrangement will move as a consequence of introduction of the Pigovian tax. The excess burden of taxation is then expressed by the area of triangle E, E', X.



Fig. 5: Excess burden of taxation

From the analysis made up to now it results that the process of internalization contains opportunity costs – lost incomes from activities which due to higher taxation will not be carried out. Further on the process of internalization itself bears costs that should not be forgotten as well. Those are particularly the costs connected with the decision on how the internalization will be carried out, its solution and last but not least on the costs that originate in the case of redistribution of finance resources that come from the transfer of taxes which are included in the prices of transportation and transport. The costs are called transaction costs.

3. EXTERNALITIES AND THE PROBLEM OF TRANSACTION COSTS

The term 'transaction costs' has always existed, however the neoclassic economics considered these costs zero. Just the socalled new institution economics (economics that deals with rise and behaviour of institutions) pays attention to this phenomenon as a factor that is of a big influence on working of economy. The transaction costs arise at any exchange relations and are part and parcel of economic system. While at private transactions, which a state does not take part in, these costs are automatically included into total costs, it is quite problematic to determine and financially quantify them when solving the problems with participation of public sector -astate and its parts as well. We can say that as for the market relationships in case of zero transaction costs all possible transactions would be carried out.

The fundamental component of transaction costs are the costs connected with transfers of payments. In private sector those are e.g. costs of selling systems (cash desks, wages of staff etc.). Research into this problem focuses on the questions of the height of transaction costs in various types of economies while it is based on the thesis of Adam Smith that the efficiency of economy and its wealth increases with the increase in the rate of its specialization not with the decreasing transaction costs.

It is a question what those transaction costs in fact are and what can be included within them. Keneth Arrow defined these costs very generally as the costs that are connected with working of economic system and that the knowledge and research into this type of costs is cardinal within the area of the theory of public choice. [2] More preciously the definition states that those are the costs connected with transfer and takeover and protection of rights considering the fact that the following items are included in it:

- finding information on distribution of prices and qualities of commodity and input working costs, finding possible buyers, sellers etc.
- · finding positions of these buyers and sellers
- concluding contracts
- observing possible partners of formal agreements
- upholding agreements and collecting damages caused by activities of unreliable partners

This distribution is valid for market transfers. It structure is different for the transactions carried out by a state, however their nature will be the same. Within the solution to externalities we can define these three basic types of transaction costs:

- costs of finding the counterparty of an agreement
- costs of negotiation on the content of an agreement
- costs of the agreement enforcement

For the party, which is stricken by the externality, is then valid the internalization (compensation) is permissible for her just if:

$$N_{EXT} + N_{TR} + N_{OP} \le P_{INT},\tag{4}$$

where:

 N_{EXT} ... external costs N_{TR} ... transaction costs P_{INT} ... internalization incomes

 N_{OP} ... opportunity costs (lost incomes from the activities that were not carried out due to taxation)

For the cases when there are few participants in the process of internalization these costs are negligible but if the number of participants increases the transaction costs increase as well and it is necessary to switch from a market mode of internalization to a mode using fiscal measures. Here, however, another problem appears. While in the case of a market negotiation all participants in the agreement are able to judge and quantify the rate of losses, which they have suffered, and include it into the agreement on compensation for damage, a state introducing fiscal measures either does not have such information or they are not sufficiently conclusive or, on the contrary, a state has such information but is not able to drive and enforce it due to various interest groups.

Simon Kuznets was an American economist of Russian origin that made research in the field of economic growth, GDP and social income inequality. He found out that the Gini coefficient as the function of GDP has the shape of a reversed U-curve, later called the Kuznets curve [3].

The environmental Kuznets curve (EKC) was introduced by the economists Grossman and Krueger [4]. It states that the environment begins to improve with the growth of GDP per capita, as e.g. better technologies start to be used after some level of welfare had been reached. Its general shape is shown in figure 1.



Fig. 6: Environmental Kuznets curve

Such function can be is modeled by a maximum third degree polynomial in the regression:

$$Y_{it} = G_{it} \cdot \beta_1 + G_{it}^2 \cdot \beta_2 + G_{it}^3 \cdot \beta_3 + X_{it} \cdot \beta_4 + \varepsilon_{it}, (5)$$

with emissions per capita Y_{it} in locality *i* at time *t*, coefficients β_{i} , independent variable average GDP per capita G_{it} , other explaining factors X_{it} and error term ε_{it} .

The basic explanation is that cleaner production and consumption technologies have been used with the economic growth. The second reason is that more wealthy countries have been transferring production and its emissions to less developed countries. However this is not the case of emissions from road transport that are discussed in this paper.

4. EKC IN ROAD TRANSPORT

Various empirical studies verify the applicability of the EKC [5], but it is necessary to interpret this dependence and to look for the reasons why the environmental deterioration decreases with the economic growth. [10] These reasons can be divided into 5 groups:

- The transition from agricultural character of the society to the industrial one during the industrial revolution was followed by the increased environmental deterioration. This is the explanation of the growing part of the EKC. This development can be today observed in the developing countries like China and India.
- The decreasing shape of the EKC can be explained by technological changes. Innovation has usually been decreasing the energy consumption rate as well as emission factors.
- The demand for better environment has been increasing with the growing wealth. People that had satisfied their basic needs (Maslow's pyramid) have been increasing the pressure on producers to get environmentally cleaner products. [9]
- More wealthy society has been asserting through its public representatives more strict environmental legislation and incentives (of economic character, i. e. consumption and environmental taxes etc.) towards behavior less harming the environment.
- The last reason relates to the transfer of production to poorer countries with lower labor cost, more wealthy countries have been concentrating to the production of services that damage less the environment. This is of course only the case of a local transfer among countries that does not decrease the total environmental damage.

For the verification of the EKC in road transport we have analyzed the emissions as function of the GDP of 16 countries of the European Union (Bulgaria, Czech Republic, Slovakia, Slovenia, Hungary, Estonia, Lithuania, Latvia, Belgium, France, Germany, Netherlands, Portugal, Austria, Sweden and UK). The emissions are averaged (per capita) in population for the purpose of comparison and the use of data from various countries.

Carbon dioxide emissions show in general (regardless the source activity) a strong linear correlation with GDP. Some authors state that the EKC concept may be inappropriate to describe the relationship between economic growth and carbon dioxide emissions [4][8]. The reason can be that carbon dioxide has been considered as a pollutant recently in connection with the problems of global warming. In the road transport, the emissions of the carbon dioxide also show an almost linear growth with GDP per capita, as shown in figure 2.

The situation of emissions of nitrogen oxides is more interesting. A final regression with a quadratic function was used that corresponds to the theoretical shape of the EKC. The graph is shown in figure 3. The results are different for various types of emissions. More important (and controlled) pollutants hydrocarbons and carbon monoxide show a slow continual decrease.



Fig. 7: Road transport CO₂ emissions as function of GDP per capita (source: Eurostat)



Fig. 8: Road transport NO_x emissions as function of GDP per capita (source: Eurostat)

5. ENERGY CONSUMPTION IN ROAD TRANSPORTATION

The consumption of energy in road transportation (in the same group of countries) is almost proportional to GDP per capita, as shown in fig. 9.



Fig. 9: Road transport energy consumption as function of GDP per capita (source: Eurostat)

The energy consumption per capita can be simply expressed as follows:

$$\frac{E}{P} = \frac{E}{Y} \cdot \frac{Y}{P} = \frac{E}{Y} \cdot y = \rho \cdot y \tag{6}$$

with energy consumption per capita *E*, population *P*, GDP *Y*, GDP per capita *y* and road transport energy intensity of GDP ρ . It means that the proportion of energy consumption in road

transport to GDP (road transport energy intensity of GDP ρ) is almost constant. [7]

The emissions per capita can be expressed as follows:

$$\frac{X}{P} = \frac{X}{E} \cdot \frac{E}{P} = e \cdot \rho \cdot y \tag{7}$$

with total emissions X, population P, road transport energy consumption E, emission factor of transport energy consumption e, road transport energy intensity of GDP ρ , and GDP per capita y. Thus the decrease of emissions per capita can be explained only by the decrease of emission factors that means mainly by the more strict emission standards EURO 1– 6 for vehicle producers and emission controls of vehicles.

7. CONCLUSION

Our data show that except for carbon dioxide, the emissions per capita from road transport decrease with the growing GDP per capita, i.e. the environmental Kuznets curve could be valid for the emissions from road transport. According to our simple analysis the explanation could be only the successful control of emissions, e.g. by the EURO standards.

Other factors like lower consumption vehicles, better transport technologies etc. seem not to contribute at the total to this decrease, because the road transport energy intensity of GDP seems to be constant. [11]

The problems of externalities in transport are not trifling so that we could only simply say that the internalization is the only one possible solution. On the contrary, it is a solution that brings a lot of snags which we can sum up in the following items:

- internalization of externalities may bring the socalled opportunity costs, which means lost incomes from activities that will not be carried out regarding a higher taxation,
- efficiency of internalization of externalities when using the so-called Pigovian taxes significantly depends on the elasticity of supply/demand (e.g. for individual transport) and if the demand is nonelastic, the effect of internalization will be weak,
- internalization may decrease competitiveness of economy and repress economic growth and consequently, as a paradox, decrease the incomes of national budget,
- the factor that cannot be omitted at internalization of externalities is transaction costs, which in the case of transport result in the solution to internalization by state measures though this also brings further transaction costs,
- externalities are significantly connected with another phenomenon which is quality of life. The next part of the work will be focused on it also regarding its connection with the economic efficiency of national economy.

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A Process Model for Goal-Based Information Retrieval

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ABSTRACT

In this paper we examine the domain of *information search* and propose a "goal-based" approach to study search strategy. We describe "goal-based information search" using a framework of *Knowledge Discovery*. We identify two Information Retrieval (IR) goals using the constructs of *Knowledge Acquisition* (KA) and *Knowledge Explanation* (KE). We classify these constructs into two specific information problems: An *exploration-exploitation* problem and an *implicitexplicit* problem. Our proposed framework is an extension of prior work in this domain, applying an IR Process Model originally developed for Legal-IR and adapted to Medical-IR. The approach in this paper is guided by the recent ACM-SIG Medical Information Retrieval (MedIR) Workshop definition:

"methodologies and technologies that seek to improve access to medical information archives via a process of information retrieval."

Keywords: Information retrieval, Medical information retrieval, Process model, Exploration, Exploitation, Implicit, Explicit, Knowledge discovery, Knowledge acquisition, Knowledge explanation.

1. INTRODUCTION

A recent review of literatures in this area [1], [2], [3], [4] suggests that there are three common research themes being pursued in the domain of Legal-IR and Medical-IR: (1) Visual display of information, (2) Incorporating external amplifying information and (3) Integrating internal explanatory information. The first theme of visual display centers on how to design a visual interactive system, to foster better user understanding of terminologies and vocabularies contained in an electronic document. The second theme of incorporating external information is concerned with how a system can be used to support a user's information retrieval need by accessing external sources. The third theme of integrating explanatory information describes the problem of interpreting text based content and assimilating domain dictionaries and lookups. In this paper we explore a specific example of this in the domain of Medical-IR where the user has access to taxonomies and libraries such as SNOMED and UMLS.

The framework described herein proposes a goal-based approach to IR using *acquisition* and *explanation* as descriptive goals serving varying user information needs and varying user knowledge levels. We propose this framework of Knowledge Discovery to design and develop IR oriented information systems, and to evaluate how well a system supports the goals of amplification of user knowledge and increased user understanding using internal and external sources.

2. DEFINITIONS

Traditional Knowledge Discovery comes from the domain of data analytics. It is concerned with the discovery of new patterns emerging from implicit information [6], with few or no pre-defined goals. An interesting characteristic of IR is that it is concretely defined by two overriding main goals: improved understanding and increased knowledge in a user specified topic scope. The "discovery" is one of understanding and amplification of knowledge using pre-defined terminologies [1]. Using a Knowledge Discovery Framework as our guide, we seek to classify information search as two distinct goals of knowledge explanation and knowledge acquisition. In this paper, we apply this classification method to the domain of Medical-IR, to leverage the predefined taxonomies and libraries available.

We define Knowledge *Explanation* (KE) as an explicit-implicit problem. This is a problem of definable, but complex terms needing to be reduced to a layman's level of understanding. We believe this definition best describes research problems centered about the goal of explaining terms that need to be better understood. The problem considers that explicit

knowledge represents information that is common knowledge or readily accessible to the layman, easily codified in written form and often found in manuals, documents, and various web media outlets (links, pages, etc.); and that implicit knowledge, represents information that is not commonly known, but its meaning is often based upon specialized knowledge of a narrowly focused community of experts in the area. This type of knowledge is sometimes called tacit knowledge [8]. The problem of translating the tacit (implicit) to the explicit has been previously defined by Nonaka in this work on social transfer theory (SECI) [9].

We apply the Knowledge Explanation construct to the instance of Medical-IR where a specific research question focuses on how to design a visual interactive system to support patient understanding of terminologies in discharge summaries using internal sources of local vocabulary dictionaries and thesauri such as UMLS and SNOMED. We categorize the terminologies in documents such as discharge summaries as implicit, insofar as their usage is operationalized as common parlance of the experts and thereby outside the knowledge base of the patient (layman). The system objective here is to convert the implicit to the explicit, to achieve the stated goal of better patient understanding [10].

We define Knowledge *Acquisition* (KA) as an exploration-exploitation problem insofar as it is an information search with the purpose of acquiring additional external documents to amplify a user's knowledge on a subject matter, topic or terminology. Knowledge Acquisition is used as a supporting construct for addressing how to provision a user's information retrieval need by accessing external sources. We define this acquisition need as a situation whereby a user desires to amplify information about a specific topic.

The exploration-exploitation problem describes the dilemma of a user's decision to focus attention and commit resources to the current selection versus abandoning it in favor of searching for a new selection. This method is operationalized by the IR process model (Figure 2) adapted to Legal-IR and Medical-IR. The process model provides a mechanism to design an interface to support the behaviors of exploration and exploitation. Exploration as a construct explains human search behavior [11]. Operational examples include electronic search and methods that support browsing. The exploration construct itself, can be further classified into extrinsic and intrinsic. Extrinsic exploration typically has a specific task purpose, whereas intrinsic exploration is motivated by learning [12].

3. APPROACH

Our approach begins with defining a framework for *knowledge discovery* (KD). In this framework we classify two distinct objectives to support the goal of improved patient knowledge and understanding. We describe these two objectives using the constructs of *Knowledge Acquisition* and *Knowledge Explanation*. Next, we apply a previously validated IR process model from the domain of eDiscovery [10], [11], adapted to Medical-IR as a mechanism to implement the KD framework and support the exploration-exploitation balance. We use the process model as a benchmarking tool for evaluating prototype systems built to support IR goals and objectives.

The original process model has been designed to support context learning and knowledge discovery. The adapted model is based on an *explicit-implicit* scheme (defined previously) to support knowledge explanation and an *exploration-exploitation* scheme to support knowledge acquisition. When we apply this approach to our Medical-IR instance, the objective of *explanation* is supported by direct injection of query expansion, using terms from internal documentation (discharge summaries) indexed against predefined taxonomies (SNOMED and UMLS). The objective of acquisition is supported using external information search with relevancy rankings based on context and content similarities.

4. FRAMEWORK

Figure 1 depicts the Knowledge Discovery Framework. Within the framework we classify knowledge discovery into the constructs of *Acquisition* and *Explanation*. The acquisition construct represents externally acquired information for the purpose of supporting patient amplification of knowledge on a topic, condition, or terminology. We apply the explanation construct in this case to the Medical-IR problem of supporting better patient understanding of a diagnosis, condition, or terminology contained within a discharge summary and indexed against a predefined taxonomy such as SNOMED or UMLS.



Figure 1: Knowledge Discovery Framework for IR

5. APPLYING A PROCESS MODEL

We assume the two goals of acquisition and explanation. Figure 2 depicts the iterative and cyclic approach to the exploration-exploitation behavior in the search process. The IR process begins with an initial search structure. This structure can be based on a specific mental model of the user, or in the case of Medical-IR, we begin with specified terminologies in the discharge summary. The system (whatever system is used) then will begin a retrieval action to suggest documents or links containing possibly relevant content. The user is presented with a "snapshot" of documents to facilitate the exploration process. The model describes three levels of exploration and simultaneous exploitation: scanning, skimming and scrutinizing. Scanning describes the superficial review of a list of titles, skimming describes a superficial review of a document selected from the list of titles, and scrutinizing describes a deeper, more critical review of the selected document.

In the goal of knowledge *acquisition*, we are focused on searching for documents that will amplify or expand the user's knowledge on a specified topic. In the example of Medical-IR, we can think of a term in a discharge summary or a condition described in a medical diagnosis. In this case we are dealing with bulk information in the form of web pages, links and other documents, similar to a conventional information search. The goal here is to *acquire* additional information on a topic or term to broaden or deepen knowledge. This is a relevancy problem (comparing potential documents, determining the most relevant and displaying a ranking method).

In the goal of knowledge *explanation*, we can apply the IR process model to support information search via an iterative cycle of balanced exploration and exploitation activities to convert the implicit (complex descriptions) to the explicit (simplified or amplified descriptions). In traditional IR problems, we are dealing with a bulk volume of documents to classify and extract. In the applied instance of Medical-IR, we are dealing with a single patient and the two information goals based on a specific document (discharge summary, medical diagnosis, or other example). In either instance, we apply the IR process model as an integration tool - In the Medical-IR application we use a text mining method to recognize known medical terminologies (appearing in the domain dictionary such as SNOMED or UMLS). These terminologies are assumed to be highly relevant, meaning that we have a strong assumption that the patient seeks amplification of knowledge in this targeted area.



Figure 2: IR Process Model (Hyman et al.)¹

"A Process Model for Information Retrieval Context Learning and Knowledge Discovery," (Under Review).

¹ Cite as: Hyman, H. S., Sincich, T., Will, R., Agrawal, M., Padmanabhan, B., and Fridy, W.,

6. CONCLUSION

The purpose of this paper has been to propose a framework for thinking about the convergent and divergent information goals in IR. We adapt the IR Process model from Legal-IR and apply this approach to an instance of Medical-IR to leverage the already existing taxonomies. We offer the methods described in this paper as a conversation starter and welcome comments and feedback from readers.

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THE ROLE OF SOCIAL CRM IN AN EDUCATION INSTITUTE: THE FEDERAL INSTITUTE OF EDUCATION, SCIENCE AND TECHNOLOGY OF RIO GRANDE DO NORTE CASE

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ABSTRACT

The organizations have passing for several transformations in recent times and increasingly treating information as an intangible asset that deserves attention and care. In this perspective, public organizations are gradually recognizing the importance of information in its workplace and for this reason are investing in better customer relationship management (CRM) systems, where noteworthy social media. This study aims to understand the role of Social CRM through social media as part of an educational institution. The institution chosen for the research was the Federal Institute of Education, Science and Technology of Rio Grande do Norte, through its Communication Department and Social Media. The research was characterized as Exploratory, qualitative approach, using even the literature followed by content analysis to the discussion of results. Data collection was conducted through a structured interview with two employees of the Communications Department of the Institution. The results showed that the IFRN established closer ties with the community through social media, however, there is still a need to improve the structure that supports this information system.

Key Words: Education institution. Social media. Social CRM.

1. Introduction

In the last decade, the rational use of information has been widely debated by academia and by organizations as well, given the importance attached to technological advancement of the features offered in the field of communication and information that enhance their broadcasts importance. Organizations had to undergo significant changes in their structures and systems to adapt to new needs imposed by the market. What once could be solved in a few hours or even minutes, today it can be solved in seconds, from a simple phone call via phone, videoconference or through social networks. A meeting, for example, can be scheduled through social media without at least a phone call or even an e- mail. Nowadays, organizations work with information instantly, allowing a strengthening relationship with its customers through customer relationship management (CRM) multifaceted able to identify their needs quickly and objectively. Social Media integrate these CRM 's in order to assist them in broadcasts mass of information , where the organization will achieve the greatest number of customers via the networks formed by customers.

These social networks seek to integrate and update people so that they are always tuned, whether at home, at work or at school, everything that happens in the world and their networks of interest. In this perspective, educational institutions as organizations have sought to engage their students in order to accelerate the dissipation of information in order to keep its network updated and informed about the actions elapsed in the institution. Teachers seek to maintain this channel with their students, allowing an extension of the classroom through the media and immediately activities.

With the aim of better understanding the role of social media in the dissemination of information system in a teaching environment, it was decided to conduct a study at the Federal Institute of Education, Science and Technology of Rio Grande do Norte (IFRN) given its wide and complex educational structure consists of 16 campus and a rectory, more than 2,000 servers and approaching 20,000 students. The century-old institution is nationally recognized for quality in their teaching. The objective of the research is to understand the role of Social CRM within an educational institution.

This study is divided into five sections. After this brief introduction, the second section of the literature review of the CRMS is made and discussed the relationship of social networks in educational institutions. The third section presents the methodology and the analysis model, then the fourth section presents the results and discussion of the study. Finally, concluding remarks are made and limitations of the study are presented as well.

2. Social CRM

In a globalized world where competition comes from all sides, it has never been so important to understand the consumer's needs. If in this scenario seems difficult to attract new customers, retaining them is an even harder task. Therefore, companies are increasingly approaching consumers and wanting to extend their degree of knowledge about them.

CRM or Customer Relationship Management is defined by Kotler (2006) as the "careful management of detailed information about every customer and every point of contact with him in order to maximize its faithfulness" (p.151). Payne and Frow (2005) explain that CRM unites the potential of relationship marketing strategies and information technology with the aim of creating a profitable long-term relationship with customers and other key stakeholders, providing enhanced opportunities to use data and information so that both understand customers and create value for them.

Therefore, according to the same authors, the CRM aims to:

• Attract, retain and satisfy customers ;

• Understand and anticipate the needs and desires of customers;

• Overcome your expectations and needs;

• Sort customers;

• Increase efficiency and effectiveness of the organization.

However, with the advent of the internet and later with the emergence of social networks, the relationship between company and customer has become more dynamic, rapid and sensitive . Within seconds a complaint Twitter (www.twitter.com), Facebook on (www.facebook.com) or YouTube (www.youtube.com) - all major social networks - on a defective product or a service done poorly can run the world and seriously damage the image of an organization . This is because such networks transmit chain in effect a large amount of information at any time and without filters, so anyone can receive any message being related or not to the author of the complaint .

For Lemon and Verhoef (2012), new channels, such as mobile phones or smart phones and new social media such as social networking sites have created new challenges and opportunities for organizations.

The SCRM - Social Customer Relationship Management, or social management of customer relationship appears just focusing on the relationship with customers in social media. Greenberg (2010) argues that SCRM is designed to engage the customer in a collaborative conversation and provide a mutually beneficial value in a trusted and transparent environment for business.

According to Chess Media Group & Lieberman (2010), the evolution of CRM to SCRM brought the following changes:

• The processes began to be defined by the consumer rather than being defined by the company;

• Instead of business hours, the consumer seeks to relate to the organization at any time ;

• Instead of channels defined relationship with the customer, the customer has several dynamic channels;

• The relationship between consumer and client no longer be transactional and interactional became;

The use of SCRM enables consumers to seek information about a product of interest in major social networks, and require quick responses of a company. In contrast, Heidemann, Klier and Probst (2012) and Holzner (2009) state that with such media organizations can analyze trends for future business opportunities and monitor the reputation of its products and services . This creates an unprecedented overview of management since enterprises are facing a new challenge of how to deal with their customers across all channels so that customer value is created and maintained (Schonfeld, 2010).

Much of the social networks is aware of these trends. Gorry (2011) reports that networks like Facebook or Twitter already offer companies the live chats, instant messages and other ways to connect employees with their consumers. Also in this sense, several organizations provide online forums to integrate the consumer with the systems and processes of new product development (Nambisan & Nambisan , 2008).

Thus, it can be seen that the relationship between company and consumer is becoming more complex, being necessary to rethink the way that organizations operate in an environment based on multiple communication channels. The following will discuss the role of social networks in educational institutions.

2.1 Social Networks and Educational Institutions

The world joined from time to social networks. According to the portal TERRA (www.terra.com.br) news, just hit Facebook in December 2012 one billion users, with most of these consisted of students. This fact could not be ignored by the institutions, since a large amount of information thrown into the network for these students may be interested in these institutions. Groups of students who take a discipline in common organize discussion on the subject discussed in the previous lesson, teachers use forums social networks to take questions from students and officers outside community keep updated on the latest achievements of the school / university towards society. These actions contribute to social networks assume important role for educational institutions. This new environment presents a different picture regarding how they manage information. The university will lose its privileged primary producer of knowledge and guardian of the same role, since knowledge becomes more accessible through other sources and is produced by more people more different ways (Armstrong & Franklin, 2008).

In general, there are several advantages for the student in building a relationship between educational institution and social networks: Madge *et al* (2009) indicates that the student engages in learning tasks get past the network; Pasek and Hargittai (2009) state that the student develops a positive attitude about learning; Hew (2011) complements the student to create their own path

of learning, for having a wide variety of tools, applications and information sources; students also have the opportunity to communicate with the teacher outside class (SELWIN, 2009). The experiences of students with social networks also bring unexpected contributions. A study by Selwin (2009) in England showed that students use social networks not only to criticize learning experiences or exchange information relevant to the courses, but also to promote their incompetence and lack of engagement.

The teacher can also benefit from the use of social networks since it: may increase the credibility of teachers engaged in contemporary student culture (Kabilan, Ahmad & Abidin, 2010); constructive educational outputs comes in a variety of fields (Penpek, Yermolayeva & Calvert, 2009); practice a different pedagogy in the best interest for the student (Hew, 2011); accepts the student as an interaction partner (Schwartz, 2009); Dabner (2011)) concludes by stating that the teacher becomes prepared to work in a digital learning environment, living in constant growth.

Thus, it can seen a trend of educational institutions to consider social networks as partners in their relationships with students, teachers and community. Following the methodology used in this research will be explained.

3. Methodology

The methodology to be adopted in conducting the proposed research is essentially exploratory in seeking to know the subject in greater depth in order to make it clearer and to build important for the conduct of research issues (Beuren , 2003 & Malhotra , 2001). In this sense, firstly, it uses the bibliography research that allows the researcher using information necessary to conduct the survey of secondary origin, obtained from documents that have been published in scientific circles. In this research, specifically, related to Social CRM in Educational Institutions.

In order to meet the objectives proposed by this study comprises the analysis of the role of social networks at IFRN, it is used the interview as a technique for collecting data stand out as one of the most widespread techniques of research and considered one of the most important for social research. Berni (2002) defines interview as a conversation initiated by the interviewer to obtain relevant data on a research problem. Gil (1999), one of the advantages of the interview is the degree of depth to the information acquired , in addition to being required of the respondent 's ability to read and write .

For this study it is chosen the use of semistructured interviews conducted in the Department of Media and Press IFRN to the coordinator of the department (R1) and an intern (R2), for allowing the use of directed questions, however open , in which the respondent can discuss freely about the topic in question (Berni , 2002) . The script of the interview questions was based on the study of Dominique Wolton (2004), by discussing the relationship of communication with society , emphasizing the evolution of communication was so immense that communicate instantly with people by the sound , the image or by words is common nowadays .

To Wolton speed and volume of information quality are not synonymous nor pluralism. The author warns that in a communication system transceiver receiver is increasingly active, but be careful with the full power of the receiver, because it could impose its dictatorship in communication.

For the same author there are three fundamental senses for communication : direct communication - is to share with others , which is disseminating the report , but also interact with an individual or a collectivity ; technical communication - either is exercised directly between two or more people , such as that mediated by techniques such as telephone, radio , computers , among others; functional and social communication - technical systems comprising of switches connected to networks and satélites.Nesse sense , thought the author gave the theoretical necessary , support for the methodological orientation of the research.

Regarding the analysis of the results , we used content analysis consisting in the analysis of texts and documents , with the goal of " critically understand the meaning of communications , its manifest or latent content , explicit or hidden meanings " (Chizzotti , 1991, p. 98) . Also adopted in this study the definition of content analysis of Bardin defined as " a set of analysis techniques of communication , that uses systematic and objective procedures to describe the content of the messages " (Bardin , 2004 p.33) .

It is considered that the work of Laurence Bardin has a consistent anchor in methodological rigor, with a supportive organization in-depth understanding of the method and at the same time, brings researchers a multifaceted way that characterizes content analysis as a method that historically and daily, produces meanings and significances in diversity sampling present in academia.

According to the author, in the apprehension of the world, in the forms of lectures, remains beyond the connotation denotation. It is at this level that the signs are exchanged, combine and inferred its meaning. A sense that should unravel ie behind, usually symbolic and polysemous apparent discourse hides.

Berni (2002) stating that complements this analysis technique is constituted as a versatile tool which enables the researcher trying to build a knowledge analyzing the speech, the arrangement and the terms used by the speaker. In this present study, the interview was recorded, transcribed and analyzed, extracting explicit and implicit meanings of the speaker for this analysis is to understand the role of social networks in School IFRN.

4. Presentation and Discussion of Results

Through the interview with the IFRN Department of Media and Press servers, we could achieve results presented in this section. Two servants, nominated for R1 and R2, which is part of this department and work directly with social media were interviewed. Initially, R1 and R2 were emphatic in stating that IFRN always seeks being closer with their academic communities, and social media are used in order to foster this narrowing, a concern that was highlighted by Payne and Frow (2005) as the basis for Social CRM. The main media used by the institution are Facebook, Twitter and "Contact Us", an answering service of the IFRN. From data collected on the Twitter page, you can identify the IFRN as the technical education institution who has more followers in the country, with a slightly higher number than 21,000 followers. (See Table 01).

Table 01 – Twitter followers per education institution

Education Institution	Twitter Followers
IFRN	21.147
IFSC	6.732
IFC	6.332
IFPB	6.247
IFAL	2.945
IFMA	2.553
IFAM	1.866

Source – Twitter (2013)

Facebook shows up quite well accessed by the community, with a number of "likers" already surpassing 10,500. This shows that IFRN is approaching its target audience and the community shows itself interested in participating in the construction of the education institution, collaborating with generating ideas and feedback of the work done by the institution.

Regarding the management of social media by the department servers, it is clear that there is not, directly, a person responsible for managing the accounts. In a collaboration system, the servers crowded in the Department of Communication and Media, unfold to meet the yearnings and doubts arising in the community, but without a certain media to be responsible to a server. According to R2,

"Indirectly there is a division, but who is currently in the sector is responsible for responding to questions that arise in the various media used by IFRN."

It is observed that the answers are given in coherence with de Institution's line of work, but without attributing responsibility to a specific server. From this perspective, publications and answers to followers and "likers" are updated on demand, however, no established daily goals responses temporally. Questions are answered as far as possible and posts are more frequent when one has to post posts that require a quick diffusion as: announcements, results in recruitment processes, etc. With the advent of Twitter and Facebook, considered instant media broadcasts, there was a closer relationship with the academic community and the community interested in the services offered by IFRN. The links were narrowed and according to R1,

"With the more frequent use of Facebook and Twitter, there was a reduction in "contact us" and the more we do it, more are the requests by the community concerned."

It is noticeable that those interested in the

institution feel welcomed when they are given more attention and quickly. The faster the answer is given to a follower, the greater is the interaction developed between the participants, which can be seen as natural, since the demand for answers is enlarged.

It appeared also that social media represents a dichotomy between the bonus and the burden of employing them in an institutional environment. According to R1:

"Social media can be considered a blessing or a curse. Blessing for what has already been reviewed and curse because of the insistence and pressure in our sector in times of selection processes, such as the selection exams or strike movements."

This revelation shows that social media plays a role of paramount importance in optimizing the dissemination of information to the interested public, as told by Greenberg (2010). Moreover, these media can bring high demands in specific periods of the appropriate sector, as the sector of Social Communication Press, which can hamper the routine work these times.

Regarding the most widely used type of social media, Facebook stands out on Twitter and "Contact Us", suggesting that the visibility of this social media fosters this result, as well as the characters limitation on Twitter that inhibits the participant to freely type comments. "Contact Us", considered a consolidated social media in organizations, have a less prevalent use, certainly because of the least instant and dynamic nature than the others.

It appears also that the IFRN recognizes the important role of social media in optimizing the dissemination of information to the servers, students and the general community, which allowed the creation of new communication facilities between these ones and this result was corroborated by Lemon and Verhoef (2012). It is noteworthy that the use of these social networks is seen by different ways to certain group of audience, as quoted below:

"Servers only use it in specific cases, such as strikes. The largest use is by students and interested community."

Thus, it can be observed that the servers, teachers and administrative technicians of IFRN does not routinely use social media to strengthen the relationship with their work environment, except during specific interests of the group. On the other hand, students and the general community interested adopt Facebook, Twitter and "Contact Us" routinely.

According to the respondents:

"It is not enough just to open the accounts, they must be fed constantly."

So, creating accounts on social media such as Facebook and Twitter, requires ongoing management by a specific sector of communication at each campus who can instantly respond and clarify doubts, in line with the guidelines set by the dean, in order to avoid disjointed and opposing information within the same institutional environment.

Being a wide educational institution, it is common to find unofficial IFRN accounts and profiles, often created by students with the purpose of disseminating news and materials related to academic routine. This often entails the mass dissemination of false or unofficial information about the Institute. So there is a concern of reporting that IFRN is not responsible by content generated by such accounts.

Moreover, as the Internet often gives its users the possibility of anonymity, you can also find offensive or disrespectful comments on the pages of IFRN. Respondents said they try to answer such offenses in the most cordial and polite as possible, and only in cases of really aggressive comments cogitate delete these posts from the page.

When finally questioned whether it was possible to educate through social media, R1 replied:

"Yes, now access to education is facilitated because of the language used. The language is informal, you're kind of talking to the student, as equals."

It can be seen that there is concordance between content analysis and speech of the above references as Selwyn and Schwartz (2009), since social networks contribute to the education of approach and facilitate communication between students and educational institutions. The next item will discuss the contributions that this research has reached.

5. Concluding Remarks

This study aimed to understand the role that social CRM exercises in an educational institution, specifically the Federal Institute of Education, Science and Technology of Rio Grande do Norte. According to the results achieved in this study, it was possible to conclude that social media plays a relevant role in the instantaneous spread of information and the approximation of the relationship between students and the general interested community.

In this sense, it is observed that the search for quick and accurate information on a specific interest in the major social media, demanded the education institution to adapt to this new reality of the information age, by not just creating Facebook accounts or Twitter, but also the inclusion of sectorial environment that worries and readily meets the demands arising from these media. However, it was observed that IFRN deals with Social CRM intuitively, since there is no effective relationship management between IFRN and interested community.

It is possible that this new stipulation requires greater coordination and integration between social media created on each campus of the Institute and the rectory, with the goal of avoiding conflicting information. The performance of the servers in social media is another important aspect that could be favored by this integration between the various campuses, since, currently, many participate in isolation and not combined with other campuses.

In this context, the intention of this study was to contribute to a better understanding of social media in a education institution that enables researchers to seek the knowledge innovation.

Finally, it recognizes that many issues still requires further research, as the possible implications for the impact these social media cause in the narrowing of the relationship between servers, students and the general interested community. Therefore, a new look able to rethink how educational institutions operate in the approximation of its stakeholders is necessary.

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Fuzzy MCDM Approach for Health-Care Performance Assessment in Istanbul

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ABSTRACT

Performance measurement in the health-care sector is a challenging task due to the wide variety in performance metrics and their interpretation. It is essential to develop a robust methodology to evaluate health-care performance since substantial and increasing amount of public resources are dedicated to health-care. With this goal in mind, this paper proposes a fuzzy decision making framework that enables to consider information imperfection such as imprecision and qualitative evaluations as well as crisp data for health-care performance assessment. Initially, a multi-criteria decision making (MCDM) approach based on fuzzy set theory and VIKOR method is employed for health-care performance evaluation of six regions in Istanbul, a metropolis with nearly 15 million inhabitants that is also among the world's most populated cities. Fuzzy TOPSIS is also used since a set of compromise solution obtained via fuzzy VIKOR does not enable a complete ranking of regions. A comparative analysis is presented to assess the health-care performance of six regions in Istanbul.

Keywords: Decision analysis, Multi-criteria decision making, Health-care, Performance evaluation, Fuzzy TOPSIS, Fuzzy VIKOR.

1. INTRODUCTION

Efficiency measurement represents a first step towards the evaluation of a coordinated health-care system, and constitutes one of the basic means of audit for the rational distribution of human and economic resources [1]. Turkey has been undergoing an important reform process called the Health Transformation Program since 2003, with the primary goal of achieving effectiveness, efficiency, and equity in organization, delivery, and financing of health-care services [2]. In order to satisfy the demands of both the public and the government to improve quality and efficiency of health-care services, various health-care performance measures have become essential.

The classical multi-criteria decision making (MCDM) methods that consider deterministic or random processes cannot effectively deal with decision making problems including imprecise and linguistic information. Many real-world problems incorporate information imperfection that can be better expressed using linguistic data such as poor, fair or good. Fuzzy sets appear as useful means to represent ambiguous, uncertain or imprecise information that cannot be properly expressed using crisp data [3]. Hence, fuzzy MCDM techniques have been used in tackling real-world decision making problems over the past two decades.

Even though the application of fuzzy decision making techniques is common in a wide variety of disciplines, there are only a few fuzzy MCDM studies published in the literature related to health-care performance assessment. Tsai et al. [4] developed fuzzy analytic hierarchy process (AHP) and fuzzy sensitive analysisbased approach to evaluate hospital organizational performance. Altuntas et al. [5] measured perceived hospital service quality using unweighted and weighted service quality (SERVQUAL) scales. AHP and analytic network process (ANP) were applied to determine a weight for each SERVQUAL dimension in their study. Buyukozkan and Cifci [6] combined fuzzy AHP and TOPSIS (technique for order preference by similarity to ideal solution) methodologies to evaluate web site alternatives of hospitals. Grigoroudis et al. [7] used balanced scorecard approach with UTASTAR method to health-care organization's the monitor overall performance. Kuo et al. [8] integrated fuzzy set theory and TOPSIS method in order to rank the failure risks in the health-care failure mode and effect analysis. Liu et al. [9] presented a VIKOR-based fuzzy MCDM method in order to evaluate health-care waste disposal alternatives for Shanghai.

The classical MCDM methods fall short of considering information imperfection due to imprecision and qualitative evaluations that are encountered in health-care performance assessment. The fuzzy modelling approach enables the decision-makers to deal quantitatively with the imprecision inherent in expressing the importance of each criterion and the preference regarding qualitative criteria by translating linguistic expressions to numerical values. Perceived service quality as a key quality performance measure of health outcome and the decision makers' importance assessment of evaluation criteria impose the need to incorporate linguistic data for conducting a comprehensive performance evaluation process. For this reason, this paper focuses on health-care performance evaluation of six regions in Istanbul using two pertinent fuzzy MCDM techniques, namely fuzzy VIKOR (multi-criteria optimization and compromise

solution) and fuzzy TOPSIS. Fuzzy TOPSIS is particularly useful when a set of compromise solution obtained using fuzzy VIKOR does not result in a complete ranking of alternatives. The proposed methodologies are based on an aggregating function representing "closeness to the ideal", which originated in the compromise programming method [10]. These methods are apt to incorporate crisp and imprecise data as linguistic variables or fuzzy numbers in a decision making problem. They also possess advantages in that they are straightforward, logical and reliable distancebased methods. These properties facilitate the use of proposed approaches in health-care performance evaluation process.

The rest of the paper is structured as follows. The following section delineates the proposed fuzzy MCDM approaches. The application of the proposed decision making methodologies to evaluate health-care performance of six regions in Istanbul is presented in Section 3. Finally, concluding remarks are provided in the last section.

2. PROPOSED FUZZY MCDM METHODOLOGIES

Evaluating health-care performance requires considering multiple and conflicting criteria including both quantitative and qualitative data. Crisp data are inadequate to express perceived service quality information that is both subjective and imprecise. In order to incorporate vagueness, ambiguity and subjectivity of human judgment into the analysis, fuzzy set theory, which was introduced by Zadeh [11], has been employed.

In this section, two MCDM methods, namely VIKOR and TOPSIS, which are both based on an aggregating function representing "closeness to the ideal", are presented in a way that enables to account for imprecise data denoted using fuzzy sets.

2.1. Fuzzy VIKOR

The fuzzy VIKOR method has been developed to tackle fuzzy multi-criteria problems with conflicting and noncommensurable criteria [12]. The method focuses on ranking and selecting from a set of alternatives, and determines a compromise solution, providing a maximum group utility (majority rule) and the minimum individual regret of opponent.

The stepwise representation of the proposed fuzzy VIKOR-based MCDM algorithm is given below.

Step 1. Construct a fuzzy decision matrix. Identify the alternatives $(A_1, A_2, ..., A_m)$ and required selection criteria $(C_1, C_2, ..., C_n)$.

$$\tilde{\mathbf{D}} = \begin{bmatrix} C_1 \ C_2 \ \cdots \ C_n \\ A_1 \begin{bmatrix} \tilde{x}_{11} \ \tilde{x}_{12} \ \cdots \ \tilde{x}_{1n} \\ \tilde{x}_{21} \ \tilde{x}_{22} \ \cdots \ \tilde{x}_{2n} \\ \vdots \\ A_m \begin{bmatrix} \tilde{x}_{11} \ \tilde{x}_{12} \ \cdots \ \tilde{x}_{1n} \\ \tilde{x}_{m1} \ \tilde{x}_{m2} \ \cdots \ \tilde{x}_{mn} \end{bmatrix} i = 1, 2, ..., m; j = 1, 2, ..., n.$$
(1)

Step 2. Construct a decision-makers' committee of Z decision-makers (z = 1, 2, ..., Z). The importance weight of each criterion and the weight vector are computed using Eq. (2) and Eq. (3), respectively.

$$\tilde{w}_j = \frac{1}{Z} \left[\tilde{w}_j^1 \oplus \tilde{w}_j^2 \oplus \dots \oplus \tilde{w}_j^Z \right]$$
(2)

$$\tilde{\mathbf{w}} = \left[\tilde{w}_1, \tilde{w}_2, \cdots, \tilde{w}_n\right], j = 1, 2, \cdots, n.$$
(3)

Step 3. Determine the fuzzy best (\tilde{f}_j^*) and fuzzy worst (\tilde{f}_j^-) values of all criterion functions, for $j = 1, 2, \dots, n$.

$$\tilde{f}_{j}^{*} = \begin{cases} \max_{i} x_{ij}, j \in B\\ \min_{i} x_{ij}, j \in C \end{cases}$$

$$\tag{4}$$

$$\tilde{f}_j^- = \begin{cases} \min_i x_{ij}, j \in B\\ \max_i x_{ij}, j \in C \end{cases}$$
(5)

where B and C denote benefit criteria and cost criteria, respectively.

Step 4. Compute the values \tilde{S}_i and \tilde{R}_i , for $i = 1, 2, \dots, m$, by the relations

$$\tilde{S}_i = \sum_{j=1}^n \tilde{w}_j \left(\tilde{f}_j^* - \tilde{x}_{ij} \right) / \left(\tilde{f}_j^* - \tilde{f}_j^- \right), \tag{6}$$

$$\tilde{R}_{i} = \max_{j} \left[\tilde{w}_{j} \left(\tilde{f}_{j}^{*} - \tilde{x}_{ij} \right) / \left(\tilde{f}_{j}^{*} - \tilde{f}_{j}^{-} \right) \right]$$
(7)

where \tilde{w}_j are the weights of criteria that express their relative importance.

Step 5. Compute the values \tilde{Q}_i , for $i = 1, 2, \dots, m$, as

$$\tilde{Q}_{i} = \nu \frac{\left(\tilde{S}_{i} - \tilde{S}^{*}\right)}{\left(\tilde{S}^{-} - \tilde{S}^{*}\right)} + \left(1 - \nu\right) \frac{\left(\tilde{R}_{i} - \tilde{R}^{*}\right)}{\left(\tilde{R}^{-} - \tilde{R}^{*}\right)}$$
(8)
where

where

$$\tilde{S}^* = \min_i \tilde{S}_i, \ \tilde{S}^- = \max_i \tilde{S}_i, \tilde{R}^* = \min_i \tilde{R}_i, \ \tilde{R}^- = \max_i \tilde{R}_i$$

and v is defined as weight of the strategy of "majority of criteria" (or "the maximum group utility"), and 1-v is the weight of individual regret.

Step 6. Rank the alternatives, sorting by the values *S*, *R* and *Q*, in ascending order. The results are three ranking lists, with the best alternatives having the lowest value. Defuzzification of a triangular fuzzy number $\tilde{B} = (b_1, b_2, b_3)$ into a crisp value can be performed by the graded mean integration representation method as follows [13]:

$$P\left(\tilde{B}\right) = \frac{\left(b_1 + 4b_2 + b_3\right)}{6} \tag{9}$$

Step 7. Propose a compromise solution, the alternative $(A^{(1)})$ which is the best ranked by the measure Q (minimum) if the following two conditions are satisfied:

C1. "Acceptable advantage": $Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right) \ge DQ$,

where $A^{(2)}$ is the alternative with second position in the ranking list by Q; DQ = 1/(m-1) where *m* is the number of alternatives.

C2. "Acceptable stability in decision making":

The alternative $A^{(1)}$ must also be the best ranked by *S* or/and *R*. This compromise solution is stable within a decision making process, which could be: "voting by majority rule" (when v > 0.5 is needed), or "by consensus" $v \approx 0.5$, or "with veto" (v < 0.5).

If one of these conditions is not satisfied, then a set of compromise solutions is proposed, consisting of:

- Alternatives $A^{(1)}$ and $A^{(2)}$ if only condition C2 is not satisfied, or
- Alternatives $A^{(1)}, A^{(2)}, \dots A^{(M)}$ if the condition C1 is not satisfied; $A^{(M)}$ is determined by the relation $Q(A^{(M)}) - Q(A^{(1)}) < DQ$ for maximum M.

2.2. Fuzzy TOPSIS

TOPSIS is a widely accepted MCDM technique due to its sound logic, and simultaneous consideration of the ideal and the anti-ideal solutions. According to TOPSIS, the best alternative would be the one that that is closest to the ideal solution and farthest from the anti-ideal solution. The ideal solution is named as the one having the best criteria values attainable, and the anti-ideal solution is determined as the one possessing the worst criteria values attainable. The relative proximity of each alternative to the ideal solution is calculated based on its distances from both ideal and anti-ideal solutions simultaneously. The preference of the alternatives is determined by ranking the calculated proximity measures in a descending order. Since an alternative with the shortest distance from the ideal may not be the farthest from the anti-ideal, and vice versa, TOPSIS considers the distances from both ideal and anti-ideal solutions [14].

In here, fuzzy TOPSIS algorithm that is apt to handle fuzzy data as well as crisp data is presented. The steps of the fuzzy TOPSIS algorithm are as follows:

Step 1. Construct the decision matrix by identifying the criteria values for the considered alternatives. Assume that there are m alternatives and n selection criteria.

Step 2. Normalize the decision matrix so that criteria values are unit-free and comparable. If there exist crisp data x_{ij} , it can be represented as $\tilde{x}_{ij} = (x_{ij}^1, x_{ij}^2, x_{ij}^3)$ in triangular fuzzy number format, where $x_{ij} = x_{ij}^1 = x_{ij}^2 = x_{ij}^3$. The normalized values for the data regarding benefit-related $(j \in B)$ as well as cost-related criteria $(j \in C)$ are calculated via a linear scale transformation as

$$\tilde{r}_{ij} = \begin{cases} \left(\frac{x_{ij}^{1} - x_{j}^{-}}{x_{j}^{*} - x_{j}^{-}}, \frac{x_{ij}^{2} - x_{j}^{-}}{x_{j}^{*} - x_{j}^{-}}, \frac{x_{ij}^{3} - x_{j}^{-}}{x_{j}^{*} - x_{j}^{-}}\right), j \in B\\ \left(\frac{x_{j}^{*} - x_{ij}^{3}}{x_{j}^{*} - x_{j}^{-}}, \frac{x_{j}^{*} - x_{ij}^{2}}{x_{j}^{*} - x_{j}^{-}}, \frac{x_{j}^{*} - x_{ij}^{1}}{x_{j}^{*} - x_{j}^{-}}\right), j \in C \end{cases}$$
(10)

where $x_j^* = \max_i x_{ij}^3$ and $x_j^- = \min_i x_{ij}^1$.

Step 3. Determine the weight vector using Eq. (3). The weight vector represents the relative importance of the selection criteria.

Step 4. Calculate the weighted normalized fuzzy decision matrix. The weighted normalized values are calculated as follows:

$$\tilde{v}_{ij} = \tilde{w}_j \otimes \tilde{r}_{ij} \tag{11}$$

Step 5. Identify the fuzzy ideal solution \tilde{A}^* and the fuzzy anti-ideal solution \tilde{A}^- as follows:

$$\widetilde{A}^{*} = \left\{ \widetilde{v}_{1}^{*}, \widetilde{v}_{2}^{*}, ..., \widetilde{v}_{n}^{*} \right\}$$

$$= \left\{ \max_{i} v_{ij} \mid i = 1, 2, ..., m; j = 1, 2, ..., n \right\}$$

$$\widetilde{A}^{-} = \left\{ \widetilde{v}_{1}^{-}, \widetilde{v}_{2}^{-}, ..., \widetilde{v}_{n}^{-} \right\}$$
(12)

$$= \left\{ \min_{i} v_{ij} \mid i = 1, 2, ..., m; j = 1, 2, ..., n \right\}$$
(13)

Step 6. Calculate the distance from ideal solution and anti-ideal solution $(d_i^* \text{ and } d_i^-, \text{respectively})$ for each alternative as

$$d_i^* = \sum_{j=1}^n d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \ i = 1, 2, ..., m$$
(14)

$$d_{i}^{-} = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_{j}^{-}\right), \ i = 1, 2, ..., m$$
(15)

where distance between the triangular fuzzy numbers $\tilde{A} = (a_1, a_2, a_3)$ and $\tilde{B} = (b_1, b_2, b_3)$ can be calculated using the vertex method as follows [15]:

$$d_{\nu}\left(\tilde{A},\tilde{B}\right) = \sqrt{\frac{1}{3}\left[\left(a_{1}-b_{1}\right)^{2}+\left(a_{2}-b_{2}\right)^{2}+\left(a_{3}-b_{3}\right)^{2}\right]}$$
(16)

Step 7. Calculate the proximity of the alternatives to the ideal solution, P_i^* , by considering the distances from ideal and anti-ideal solutions as

$$P_i^* = \frac{d_i^-}{d_i^* + d_i^-}, i = 1, 2, ..., m.$$
(17)

Step 8. Rank the alternatives according to P_i^* in descending order. The alternative with the highest P_i^* value will be the best alternative.

3. HEALTH-CARE PERFORMANCE ASSESSMENT IN ISTANBUL

Health-care sector possesses too many dimensions to be fitted into a simple singular unit, and thus, assessing the performance of health-care services is a highly challenging task [16]. Moreover, there are no standard performance measures for the health-care sector since each provider, consumer and payer defines the performance of health-care based on his/her objectives, interests and interpretations.

Health Directorate of Istanbul defined six regions for health-care management purposes in Istanbul. These regions are as follows:

> Region 1 (R_1) : North Anatolian Region 2 (R_2) : South Anatolian Region 3 (R_3) : Beyoglu Region 4 (R_4) : Fatih Region 5 (R_5) : Bakirkoy Region 6 (R_6) : Cekmece

The criteria used for performance assessment of the regions and their explanations are given below.

Beds (C_1) : The total number of fully staffed hospital beds.

Clinical-staff (C_2) : The total number of specialists, general practitioners, nurses and midwifes.

Non-clinical staff (C_3) : The total number of administrative staff, technical staff and other supporting staff.

Operating expenses (C_4) : The amount of operating expenses measured in TL, excluding capital and depreciation.

Outpatients (C_5) : The total number of patients to outpatient departments and emergency rooms.

Discharged patients (C_6) : The total number of discharged patients.

Adjusted surgeries (C_7) : The total number of surgical interventions undertaken. Given that surgical interventions vary by the resources consumed, they are grouped as minor, medium and major surgeries based on the results of an earlier study conducted in Turkey [17]. Major, medium and minor surgeries are converted into a major surgery equivalent with the respective weights of 1, 1/3 and 1/7 [2].

Tangibility (C_8) : Health-care facility physical characteristics.

Responsiveness (C_9) : Staff responsiveness to patients' needs.

Empathy (C_{10}) : Individualized attention and caring provided to patients by hospital staff.

The data used in this study are obtained from Health Directorate of Istanbul for the year 2010 and the state hospitals operating in the predefined regions in Istanbul. Tangibility, responsiveness and empathy criteria are included as quality performance measures of health outcome in order to measure patient perceived service quality. Perceived service quality is measured considering these three dimensions via a survey study. A protocol is signed with Health Directorate of Istanbul to obtain the permission to apply the questionnaire in the state hospitals. This pilot study consists of 100 randomly chosen patients who receive treatment as inpatients or outpatients in the state hospitals in the respective regions.

Initially, fuzzy VIKOR is applied in order to evaluate the health-care performance of the regions.

In this study, decision-makers used the linguistic variables "very low (VL)", "low (L)", "moderate (M)", "high (H)" and "very high (VH)" to express their evaluations for tangibility, responsiveness and empathy criteria as well as to assess the importance degrees of

criteria. The linguistic terms are defined as shown in Table 1.

Table 1. Linguistic term set			
Very Low (VL)	(0, 0, 0.25)		
Low (L)	(0, 0.25, 0.50)		
Medium (M)	(0.25, 0.50, 0.75)		
High (H)	(0.50, 0.75, 1.0)		
Very High (VH)	(0.75, 1.0, 1.0)		

The evaluation is conducted by a committee of five decision-makers, which consists of hospital managers and university professors. The five decision-makers used the linguistic variables denoted in Table 1 to assess the importance of the evaluation criteria as shown in Table 2.

 Table 2. Importance weights of evaluation criteria

Criteria	DM_1	DM_2	DM_3	DM_4	DM_5
C_1	Η	VH	М	М	М
C_2	Μ	М	Н	М	Н
C_3	L	М	L	L	Μ
C_4	Μ	VH	Н	Н	Μ
C_5	Μ	Н	Н	Н	Н
C_6	VH	VH	VH	Н	Н
C_7	Μ	Н	Н	М	Н
C_8	Η	М	Μ	L	Н
C_9	Η	VH	VH	Н	VH
C ₁₀	Μ	VH	Н	М	VH

The fuzzy best and fuzzy worst values of all criteria are computed with respect to Eq. (4) and Eq. (5), respectively.

Next, the values for *S*, *R* and *Q* are calculated by Eqs. (6) - (8), respectively. In this study, the value of v is set to 0.5 in line with earlier research works [9]. The results are given in Table 3.

Table 3. The values of S, R and Q for v = 0.5

Regions						
	R_1	R_2	R_3	R_4	R_5	R_6
S	4.259	3.582	2.956	3.031	4.180	2.225
R	0.688	0.692	0.552	0.470	0.875	0.875
Q	0.734	0.586	0.273	0.193	0.971	0.500

The performance ranking of the six regions summarized in Table 4 shows that R_4 is the highest ranked region according to R and Q. As condition C1 is not satisfied, a set of compromise solution is identified as R_4 and R_3 since $O(q^{(4)}) = O(q^{(3)}) = 0.000 \pm 0.200$

since $Q(A^{(4)}) - Q(A^{(3)}) = 0.080 < 0.200$.

Table 4. Rankings with respect to S, R and Q

By S	$R_6 \succ R_3 \succ R_4 \succ R_2 \succ R_5 \succ R_1$
By R	$R_4 \succ R_3 \succ R_1 \succ R_2 \succ R_5 \sim R_6$
By Q	$R_4 \succ R_3 \succ R_6 \succ R_2 \succ R_1 \succ R_5$

Since a set of compromise solution obtained using fuzzy VIKOR does not enable a complete ranking of regions, fuzzy TOPSIS is employed to check the validity of the results obtained via the proposed fuzzy VIKOR methodology and determine the best region with respect to health-care performance in Istanbul.

The weighted normalized fuzzy decision matrix is calculated by employing Eq. (11). Then, the ideal solution and the anti-ideal solution can be respectively determined using Eq. (12) and Eq. (13) as represented in Table 5.

Table 5. Ideal and anti-ideal solutions

Criteria	~*	~_
	A	A
C_1	(0.400, 0.650, 0.850)	(0.000, 0.000, 0.000)
C_2	(0.350, 0.600, 0.850)	(0.000, 0.000, 0.000)
C ₃	(0.100, 0.350, 0.600)	(0.000, 0.000, 0.000)
C_4	(0.450, 0.700, 0.900)	(0.000, 0.000, 0.000)
C_5	(0.450, 0.700, 0.950)	(0.000, 0.000, 0.000)
C_6	(0.650, 0.900, 1.000)	(0.000, 0.000, 0.000)
C_7	(0.400, 0.650, 0.900)	(0.000, 0.000, 0.000)
C_8	(0.155, 0.421, 0.754)	(0.115, 0.343, 0.661)
C_9	(0.297, 0.630, 0.903)	(0.183, 0.477, 0.780)
C ₁₀	(0.291, 0.619, 0.868)	(0.230, 0.532, 0.786)

Finally, Table 6 provides both the distance from ideal and anti-ideal solutions for each region $(d_i^* \text{ and } d_i^-)$ and proximity of the regions to the ideal solution (P_i^*) that are computed as defined in Steps 6 and 7 of the fuzzy TOPSIS algorithm, respectively.

Table 6. Results obtained from fuzzy TOPSIS

Regions	d_i^*	d_i^-	P_i^*	Ranking
R_1	2.807	2.164	0.435	6
R_2	2.565	2.399	0.483	5
R_3	2.319	2.649	0.533	3
R_4	2.255	2.711	0.546	1
R_5	2.542	2.441	0.490	4
R_6	2.273	2.688	0.542	2

As it can be observed from Table 6, the rank-order of the regions is $R_4 \succ R_6 \succ R_3 \succ R_5 \succ R_2 \succ R_1$. Fatih (R_4) appears as the best performing region, followed by Cekmece (R_6) and Beyoglu (R_3). The results of both fuzzy MCDM algorithms reveal that Fatih (R_4) ranks as the best region regarding health-care performance in Istanbul. Cekmece (R_6) is ranked as second according to fuzzy TOPSIS and is also a high performer according to maximum group utility in fuzzy VIKOR since it yields the lowest values for cost-related criteria such as number of beds, number of clinical and non-clinical staff and operating expenses, and highest values for quality

performance indicators (tangibility, responsiveness and empathy) among the six regions.

4. CONCLUSIONS

Performance measurement plays a crucial role for the management and improvement of health-care organizations. Thus, health-care performance assessment has become a major concern for health policy-makers and health-care managers. The use of MCDM in performance evaluation has the advantage of rendering subjective and implicit decision making more objective and transparent [18].

This paper presents fuzzy MCDM approaches that enable the consideration of both exact and linguistic data in order to obtain performance ranking of six regions defined for the health-care policy making in Istanbul. Tangibility, responsiveness, and empathy are selected as quality performance indicators that are represented via linguistic variables in order to quantify the inherent imprecision in patients' assessments. The health-care performance ranking of regions is determined by using fuzzy VIKOR and also verified by fuzzy TOPSIS method. The outcomes of the analysis will help health policy-makers to take strategic action involving resource planning, allocation and utilization decisions for low performing regions.

The proposed framework is a sound decision aid for providing a roadmap to enhance the performance of health-care services. Future research will focus on implementing the proposed methodology for assessing health-care performance over a nationwide scale.

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ACKNOWLEDGEMENT

This research has been financially supported by Galatasaray University Research Fund under Grant 14.402.001.

Risk Reduction in Critical Road Infrastructure in Central Europe

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ABSTRACT

Risk reduction in critical infrastructure is one of the important parts of the critical infrastructure protection. The each EU country has an interest to prepare adequate own criteria for integration of potential objects into the European, national or regional critical infrastructure. The implementation of different methods for risk reduction in road transport in the European Union leads the individual member countries to seek ways to effectively and timely implement new procedures to risk identification and critical infrastructure protection. Individual subsystems of road transport should be analysed and assessed separately. The authors draw attention to the large and rich results of research in the field of risk assessment in road transport infrastructure with focus on bridges and tunnels (road transport objects). The results of the examination are published for the first time and should lead to professional public debate.

Key words

Road infrastructure objects, bridges, tunnel, risk reduction, risk analysis

1. INTRODUCTION

Current applied sciences and the need for practical knowledge are leading to the cooperation of academic and research teams with the experts on practise. Safety of transport and of critical infrastructure (next CI) in road transport leads to gradual implementation of the different methods. However, the very first step is the applied research in the given field. As part of national and international research projects [3,4], partial tasks have been solved which are applicable in the implementation of adequate methods. The counterpart of transport safety is the hazard or threat of maintenance processes. Risk is the potential possibility of violation of the transport system safety which can be calculated by multiplying the likelihood of incident and the amount of its negative impact. Hazards, threats and risks in transport are mutually conditional. The real incidents usually happen when more threats are combined as well as when being in function. Safety and risk possess a probabilistic character.

Their values lie in the range from 0 to 1 and their sum is always equal to 1. Analysis of potential impacts, that is subject of many recent researches, is also very important task. [5]

2. SPECIFIC RISK ASSESSMENT IN ROAD TRANSPORT

Significant part of the risk assessment in the road transport is the usage of adequate methods. 2500 theoretically possible threats have been defined in our large research, which have been subsequently reduced to 585 threats concerning the road transport. Theoretically as well as practically, various threat classifications are being used. One of the possibilities is dividing them in the following way:

- according to the object of threat activity, there are threats of non-military, military and combined character,
- according to the range of shielded interests, there are partial and complex threats,
- according to the location of threat source in the given system, there are internal and external threats,
- according to the threat source, there are anthropogenic threats and threats not dependent on human activity. [6]

Determination of causes of critical situations on roads and highways

The "cause" has been perceived by the investigators as primary action which activated the risk. Causes have been divided into two basic groups (natural and human). The next step was to allocate the causes to their risk origin activation, which had already been referred to a location in the previous step, such as road infrastructure, interchanges, tunnels, bridges and constructions of vehicles. Substantiality of these generated combinations always needs to consider. For the cause selection, existing list of causes has been used which respected the causes of critical situations filed in the type plans created by competent body and therefore, even causes which are improbable and their effect on road transport is negligible have been worked with. More causes have been calculated with while creating the name of type threats. By their analysis and classification, 14 groups of causes were generated according to their common significances, which can be found in Table 1. They are inscribed in the type threat name with their title in column "cause name". [3, 4, 7, 8]

	Change in maintenance conditions				
Cause	Objects				Together
	infra-			Surround-	
	structure	Tunnel	Vehicle	ings	
Atmospheric and cosmic defects	13	6	7	2	28
Collective public dissatisfaction	2	6	8	4	20
Criminal activity	32	25	17	7	81
Defects on Earth's surface	18	22	4	3	47
Errors in supplies essential for maintenance	7	7	1	2	17
Errors of transport crew	12	13	4	2	31
Extreme natural phenomenon and weather	32	22	14	5	73
Human factor failures	26	26	10	3	65
Negative situation in nearby countries	0	7	8	1	16
Problems in state administration	4	5	0	1	10
Public unrests	5	21	9	5	40
Special biological events	5	7	5	3	20
Technical error	27	27	11	3	68
War conflict	27	27	10	5	69
Together	210	221	108	46	585

After the threat assessment it is crucial to follow the ISO norms (also National Technical Norms) concerning risk management. According to these norms, following steps must be implemented:

- definition of the connectivity and identification of risk sources, see Fig.1,
- estimation of probability and consequences (risk calculation),
- risk evaluation risk matrix , see Table 2.

In the scope of connectivity definition, it is crucial to set a concrete object of examination. Risk source identification of road tunnels is focusing on examination of:

- floods,
- landslides/mass unrest,
- avalanches,
- other natural forces (e.g. ice),
- terrorist attacks,
- explosion, fire or leakage of transported material,
- suicides,
- vandalism criminality,
- wild animals injuries,
- technical malfunction/defects,
- human factor fault,
- vehicle or plane crash on the road transport objects, etc. [5, 6]



Fig.1 Road transport risk sources

The above listed threats are the cross section of possible launching events which might consequently lead to an incident. It is feasible to divide them into the categories according to the impact they have on tunnels as constructions, meaning whether the threat arises from the surroundings of the tunnel or from the processes or conditions inside the tunnel tube. [8] Table 2 Fragment syntax of creating the name for hazard type according to the developed matrix

Event	Risk source activation	Location	Cause
Change of operational conditions due to	Bombardment of road vehicle	Outside of road tunnel	Atmospheric and cosmic anomalies
Change of operational conditions due to	Immobility of vehicle	Inside of road tunnel	Mistake caused by human factor.

3. RISK ANALYSIS OF INCIDENT OCCURRENCE INSIDE THE ROAD INFRASTRUCTURE

3.1. Probability of incident occurrence inside the tunnel

While solving the research tasks we have come to conclusion that the most suitable procedure for the calculation of incident formation probability inside tunnels consists of 2 parts. Firstly, it is crucial to calculate the probability that an incident is formed directly inside the tunnel. Secondly, the probability of an incident in road transport as such.

Incident location probability (hereinafter ILP) can be calculated by dividing the total length of objects by the total length of roads. The result indicates probability of objects being the area of an incident. We also need to consider the probability of a road incident having an impact on the incident occurrence probability inside objects. The actual calculation of incident occurrence probability inside tunnels emerges from the total length of tunnels in Slovakia roads (7,41 km) divided by the total length of roads (17787 km) [5, 6, 17, 18].

ILP = 7,41/17787

ILP = 0,000417

This result shows that the probability of a road incident which is formed directly in an road tunnel is $4,17*10^{-4}$.

(1)

3.2. Probability of an incident occurrence in road transport

The statistics show that average transport distance of goods transport is 59,5 km. In 2011, the total number of performances for transport goods in Slovakia was 29093 mil ton-km. [14] The number of realized goods transportation in Slovakia was calculated as the ratio between road performance for transport goods (in ton-km) and average transport distance: 29 093 000 000/59,5 = 986 203 389 (2)

In 2011, number of 13252 road incidents took place. Probability of an incident occurrence in road transport is calculated as the ratio between the number of road incidents and the number of realized goods transportation: $13252 / 986 203 389 = 1.34.10^{-5}$ (3)

$$152527700205507 = 1,54.10$$
 (5)

Then the total probability of an incident happening in road tunnel is: $PVMUT = 4,17. \ 10^{-4} * 1,35.10^{-5}$ (4)

 $PVMUI = 4,17,10^{-9} + 1,35,10^{-9}$ (4) $PVMUT = 5,62,10^{-9}$ The value of 5,62.10⁻⁹ shows the probability of an incident in road goods transportation in road objects of roads and motorways of the Slovak Republic.

3.3. Theoretical aftermath of an incident occurrence in road transport

Total aftermath is calculated as the sum of death and injury casualties and material damage. Since there has been no evaluation of life in the Slovak Republic, I have used the method of scientific evaluation from the Czech Republic. The life value has been determined to 700 000 EUR. Total number of death casualties is 223 excluding the ones at roads and highways in 2013: 223*700 000 = 156 100 000 EUR [12] This value divided by the number of unit vehicle is 156 100 000/2 622 939 = 59,5 EUR/unit vehicle.

Total number of 1086 injuries excluding those at roads and highways:

10 886*70 000 = 762 020 000 EUR.

Idealised value of injury for the purpose of research was calculated to be 10% of the life loss value which means 70 000Eur, the exact value is: 762 020 000 /2 622 939 = 290,5 EUR/unit vehicle. 13]

Material damages excluding those at roads and highways are 4 533 693 EUR. Total damages are sum of death, injuries and material damages: $156\ 100\ 000\ +\ 762\ 020\ 000\ +\ 4\ 533\ 693\ =$ 922 653 693 EUR.

Very important part of research was oriented on accident black spots. Solving the black spot which are on Trans European Networks (TEN) is the most important task in enhancing road safety and security. From all the achieved results, it is feasible to calculate the risk of an incident in road tunnels from the following:

(5)

R = probability * aftermath $R = 5,62.10^{-9} * 1,85.10^{-2}$ $R = 1,04.10^{-10}$

The evaluated risk of an incident occurrence in railway tunnel being $1,04.10^{-10}$ is relevant to recommended values which are being used by German and English transport systems. (in the level from 10^{-9}). [15]



Fig. 2 Actual black spots on North West Slovakia Source [17]

3.4 Determining potential elements of CI according to sectorial criteria and their thresholds

Sectorial criteria - set out specific conditions under which the individual elements of the infrastructure in the sector can be identified as potential elements of CI. These criteria establish conditions to assess the effects of the disruption or destruction of the elements of the entire sector, or assess the impact on other sectors. An example of such sectorial criteria for determining which elements of CI in the sector transport are in focus is allowing a preliminary assessment of the consequences of their disruption or destruction on the functioning of the sector. The sectorial criteria shall also determine their quantifiable thresholds. Critical infrastructure for the transport sector in general is made up four sub sectors and our attention is oriented on sub sector road transport. Individual modes are complex stochastic systems consist of transport infrastructure, means of transport technologies to manage traffic, carriers, legal and technical standards, as well as staff and customers in the transport system.

The sectorial criteria are strict on the optimal selection of the critical elements of transport infrastructure on the basis of international experience and the state of current knowledge including: basic measurable parameters of transport (particularly intensity, event. throughput), technical parameters and environmental conditions (load trucks, the length of the tunnel and nature of the bridge structure, etc.), intensity necessary to restore (cost and duration of the recovery of the original operating parameters), the total cost of the ruined building a temporary detour, or other such e.g. cultural and historical uniqueness of the building, and so on. [1, 2]

It is obvious that precisely determined sectorial and cross-cutting criteria are relatively complicated, especially with regard to complexity and structure of stochastic transport system. Their determination is affected by subjective opinion of expert who usually assigns different weight to particular criterions.

Evaluation of sector criteria in the road transport

Based on scores of sub-criteria evaluation it is possible to determine the total score criterion by which the element can be assigned to road traffic in CI. The sum of all the criteria K1-K8 is in the range (8-56). If we assume that objects relevant for international corridors will obtain average values four points in each sub-criterion, then the resulting value will be 28 points. The boundary for inclusion of object into the components of CI should be at higher level. If we choose a threshold of 38 points, it will mean that at least six values will be with 5 points (large) and two points at level 4 (medium). A priori we do not expect individual assessment at 7 points (extreme), because in normal conditions, it is not happening.

K = K1 + K2 + K3 + K4 + K5 + K6 + K7 + K8 [-] (6)

If the calculated value is below 38 points, considered object should not be included as the potential element of national critical infrastructure of Slovakia.

	Table 3 Folin e	evaluation cinterna for foad u	anic I. class (cinena KI – K	(4)
Value of	K1 - transport	K2 - size and character	K3 - cost to restore	K4 - material value of
criteria	parameters	of object	functionality	the object
1	300 cars/24 hours	300 euros/ 1 day	50 euros/ 8 hour and	up to 300 euros
minimum			small)	_
2	1000 cars/24 hours	1000 euros/ 1 day	100 euros/ 8 hour	up to 1000 euros
negligible				
3	5000 cars/24 hours	10 000 euros/ 1 week	1000 euros /1 day	up to 10 000 euros
small				_
4	10 000 cars/24 hours	100 000 euros /1 month	10 000 euros /1 week	up to 100 000 euros
medium				_
5	20 000 cars/24 hours	1 mil. euros /1 year	100 000 euros /1 month	up to 1 mil. euros
high				_
6	40 000 cars/24 hours	10 mil. euros / 1 year	1 mil. euros / 1 year	more than 1 mil. euros
very high		and more		
7	80 000 cars/24 hours	30 mil. euros / 1 year	10 mil. euros / 1 year	more than 10 mil. euros
extreme high		and more		

Table 3 Point evaluation criteria for road traffic I. class (criteria K1 – K4)

Table 4 Point evaluation criteria for road traffic I. class (criteria K5 – K8)

Value of criteria	K5 - economic impact	K6 – uniqueness of the object	K7 – probability of an attack on the object	K8 – probability of an extraordinary event
1 minimum	up to 0,001 % GDP	minimum	> 1x in 300 years	> 1x in 300 years
2 negligible	up to 0,01 % GDP	negligible	> 1x in100 years	> 1x in 100 years
3 small	up to 0,1 % GDP	small	> 1x in 10 years	> 1x in10 years
4 medium	up to 0,5 % GDP	medium	> 1x in one year	> 1x in one year
5 high	up to 0,7 % GDP	high	> 1x in one month	> 1x in one month
6 very high	Up to 1 % GDP	very high	> 1x in one week	> 1x in one week
7 extreme high	more than 1 % GDP	extreme high	> 2x in one week and more	> 2x in one week and more

4 CONCLUSIONS

Implementation of adequate methods in road transport and infrastructure companies in the European Union is one of the crucial objectives. While doing the risk research it is important to have all relevant information about the probability of occurrence and the aftermath of each risk available. Calculations presented in Chapter 3 are the contribution of authors from international discussion about the evaluation of road transport risks. Mutual activity of several factors usually leads to the occurrence of an incident. Therefore, it is important to implement adequate safety measures into the risk management in order to decrease if not completely eliminate the risks.

One of the possibilities is to create a generally usable list of safety measures to enhance the safety of road bridges and tunnels in the time of transport. As the research shows, the highest risk of an incident in road tunnels is being formed especially during the transport. Needless to say, the aftermath can be catastrophic if dangerous materials are being transported. One of the solutions could be to prepare technical measures, such as using the RFID technology. Installation of a single chip enables the monitoring of a road vehicle.

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This paper was supported by project:

APVV 0471-10 Critical Infrastructure Protection in Sector Transportation

Small and Medium-Sized Enterprises Business Risks in Slovakia

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ABSTRACT

The aim of this contribution is to present the results of our research oriented on the business risks in Slovakia within SMEs, to analyze the results of this research and to propose the measures for the SMEs in Slovakia how to manage their risks. Within this research more than one hundred SMEs acting in Slovakia are participating. The survey is concentrated on finding the business risks in Slovakia considered by the managers to be the most important from the view of their future growth and existence. These risks will be analyzed with use of quantification methods and the most important risks of the Slovak SMEs will be evaluated. In conclusion we are going to propose measures for the SMEs how to apply the risk management to be able to identify their risks early, to prepare prevention measures for them and so to come near their prosperity and growth.

Keywords: enterprise, risks, analysis, evaluation, survey.

1. INTRODUCTION

At present the Slovak Republic belongs to the attractive business localities. It is a young country with strategic location in the heart of the Europe, member of the NATO and also member of the European Union as well as the Eurozone. In the last years the Slovak investment climate considerably increased. Slovakia is one of the most rapid reformists in the world that implements pretentious reforms almost in all spheres (taxation, monetary incomes, social and labor markets, management of public finance and decentralization, health care). The human capital of the Slovak labor power is high qualified [4].

2. DEFINING THE PROBLEM

2.1. Analysis and evaluation of the SMEs environment in Slovakia

In the actual report on global competitiveness elaborated by the World Economic Forum (Global Competitiveness Report 2013-2014) published in 2013, the Slovak Republic was ranked 78 on the list of 148 countries [12]. This competitiveness analysis is based on the Global Competitiveness Index (GCI) defined as a comprehensive tool that measures the microeconomic and macroeconomic foundations of national competitiveness. It

includes twelve pillars of competitiveness: evaluation of public and private institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication and innovations. The GCI score is based on the public accessible statistical data and results of the world wide executive opinion survey [13].

Small and medium-sized enterprises (SMEs) are in Europe as well as in the world considered as an important pillar and stabilization factor of country economy and its regions. Small and medium-sized enterprises contribute to the solution of economic, politic and social problems of the country. In the last years the rapid growth of the SMEs number is evident in Europe as well as in the world. This fact is confirmed by basic statistical data declaring that SMEs have become a basic pillar of the European economy [8].

Accession of the Slovak Republic to the European integration structures has opened new opportunities also for the SMEs. Establishment of the EU's single market, that adumbrated transformation of single national markets into one great international market with huge potential without internal borders and that involves now more than 500 million people, was one of the most important successes of the European integration. Within the EU's single market (sometimes also called the "internal market") people, goods, services and money can move around the EU as freely as they do within a single country instead of being obstructed by national borders and barriers and so there is an opportunity for the SMEs to establish themselves in this market and offer their products and services to the customers from the whole Europe [3].

Within the Program of the Small Business Act (SBA), for the purpose to gain view and understand the latest trends and internal policies concerning the SMEs, the surveys about basic economic facts are realized in each year. In the SBA 2012 analysis Slovakia is characterized as a country where [5, 6], see Fig. 1:

- Share of the SMEs sector in Slovakia amounts to 99, 2 %.
- Large enterprises represent 0, 8% of all SR business.
- Micro enterprises have the greatest share.
- Medium-sized enterprises produce the greatest contribution to the added value.



Fig. 1 Share of the SMEs and large enterprises in Slovakia from the view of number, employment and added value [6]

Globally the SMEs in Slovakia contribute to the added value and employment less than the European average. This can be caused by industrial structure of the Slovak economy. SMEs in Slovakia continue in their fight with small growth. Although the added value, produced by the SMEs indicates now very gentle growth curve, it is still markedly lower against the top in year 2008. As results from Fig. 2, the only field, where Slovakia achieves better results than the EU average, is use of advantages offered by the single market. Slovakia proceeds more rapidly than other EU countries in acceptance of legal rules related to the single market and taking legal rules of the EU into domestic law. In other fields the results are worse than the EU average (see Fig. 2).



Fig. 2 SBA Profile in Slovakia [6]

Within the developed economies SMEs are considered the most flexible, effective and progressive part of economy. In comparison with large enterprises, SMEs are more sensitive to the changes in business environment that are always, with certain time interval, transferred to the qualitative characteristics of this sector. According to the Global Entrepreneurship Monitor 2012 [14], Slovakia has the second highest degree of business termination in Europe due to nonprofitability. That is why we would like to deal with risk management in the field of the SMEs. We want to assist the enterprises to be able to know their weaknesses, to be able to eliminate them and so to become prosperous.

2.2. Analysis and assessment of SMEs business risks in Zilina region in Slovakia

The approach of the Slovak entrepreneurs to the risk management in comparison with developed countries is less systematic. In the Slovak conditions the business risk measure is perceived with different intensity but the business risk reality is considered by majority of the firms [10]. Although majority of the managers declare the need to assess and solve the risks, solutions are often limited only to the un-formal risk assessment. More sophisticated methods of risk assessment (often with support of special computer applications) are applied in firms acting in financing, energy and manufacturing enterprises (mechanical engineering, chemical industry). Firms of other business branches usually lag behind [1].

In year 2013 the statistical research of the SMEs business risks in Zilina region, within the project FaME/2013/MSPRISK: "Actual trends of SMEs business risks in selected regions of Czech Republic and Slovak Republic, was realized. The participants of this project are Tomas Bata University in Zlin in Czech Republic, Pan-Europen University in Bratislava, University of Zilina and University of Trencin in Slovakia. In Zilina region 164 SMEs through empirical research were addressed through surveys and talks with competent representatives of SMEs.

From the SMEs addressed in Zilina region, 38% have carried business more than 10 years, 32% have carried business from 5 to 10 years and 30% have carried business from 1 to 5 years. From the view of the structure, the great deal presented enterprises carrying their business in other fields 38% (consulting, distribution, etc.), 20,73% have carried business in commerce, 17,07% in manufacturing, 16,46% in building industry, 6,10% in transport and 1,22% in agriculture. According to the number of employees, in the survey participated:

- 66% micro enterprises,
- 20% small enterprises,
- 14% middle enterprises.

From the total number of 164 addressed SMEs, 30% (132) businessmen identified market risk as the greatest risk, followed by financial risk 22% (96) businessmen, personal risk 14% (63) businessmen, legal risk 14% (61) businessmen, safety and security risk 12% (54) businessmen and 8% (37) businessmen consider operational risk as the least important. The percentage indication of SMEs identified risks is given in Fig.3.



Fig. 3 Percentage indication of SMEs identified key risks in Zilina region

In Zilina region 80,49% of businessmen specified market risk as the key business risk of the present time. Business risks of SMEs in Zilina region are analysed at Fig. 4:

- Blue column indicates importance or key signification of business risk of addressed SMEs (calculated as the share of respondents who indicated respective answer from the total number of addressed enterprises).
- Red column indicates average value of identified SMEs risks (calculated as arithmetic average of values specified by businessmen in Zilina region).

The survey have brought also these results:

- 67,68% of enterprises are able to manage financial risks in a high degree,
- 23,17% of enterprises claim that they are able to manage financial risks properly,
- only 1,83% think that are not able to manage financial risks,
- 49,39% of enterprises think that their enterprise will survive the next five years,
- 40,85% of enterprises think that they certainly survive another period,
- 9,76% of enterprises think that they will survive the next five years with great doubts or they do not survive at all.



Fig. 4 Percentage indication of importance and average value of identified risks of SMEs in Zilina region

The Fig. 5 indicates 70,12% of SMEs in Zilina region reduced their performances up to 50% in comparison with pre-crisis period and 29,88% of SMEs reduced their performances above 50% in comparison with pre-crisis period.

The survey also paid attention to the change of profitability of SMEs in comparison with pre-crisis period:

- 26,22% of enterprises mentioned that their profitability markedly decreased (more than 20%),
- 37,20% of enterprises mentioned only slow decrease (0-20%),
- 21,34% of enterprises think that their situation is stabilized,
- 12,08% of enterprises claim that their profitability easily increased (0-20%)
- 2,44% of enterprises of addresses enterprises think that

their profitability markedly increased (more than 20%).

The results found out from the research of business risks in Zilina region in Slovakia underline the need to prepare for the snares of present business environment. It is necessary to enhance the knowledge level of enterprise owners (especially in micro-enterprises) about possible causes and consequences of a risk as well as about adequate measures for their reducing. Therefore enhancing the level of risks management in the SMEs requires also to obtain theoretical knowledge about specific activities of the risk management process, methods and tools usable in risk management. Absence of risk management can be one of the basic reasons of business failure and loss of competitive advantages in variable business environment in Slovakia.



Fig. 5 Percentage indication of SMEs actual performance degradation in comparison with pre-crisis period

3. PROPOSAL OF THE RISK MANAGEMENT PROCESS FOR THE SMEs IN SLOVAKIA

Although the risk management is not able to ensure the prosperity and successful enterprise functioning completely, it essentially decreases danger of business failure, allows to understand risks and take into consideration not only threats but also opportunities coming with risks. For the SMEs it is necessary to be able to apply risk management process as a factor of increasing enterprise value. We propose the risk management process adjusted to the needs of small enterprises owners and top managers of middle-sized enterprises based on the standard ISO 31000:2009 [7] and comprising the activities as follows:

1. Establishing the context

Except analysis of internal and external environment just in this stage the SMEs should define strategic and organizational relations with risk management where the process will run [2]. Further the criteria, necessary for considered risks assessment, should be defined. For analysis of current situation can be used analyses of macro environment (PESTLE, STEEP, analyses of competitive environment and others). Summarization of these analyses results can be realized through SWOT or SPACE analysis.

2. Risk assessment

Risk assessment in SMES is very important because if the enterprise does not know or is no table to designate and evaluate the risks then it exposes itself, the employees, customers and partners to danger of failure or losses of various forms. Within this stage the SMEs should identify, analyze and assess.

- Risk identification this stage is focused on identification of all risks sources that influence small and middle-sized enterprise and provides them initial assumptions for risk analysis. It is based on the results of previous stage where all negatives, weaknesses and threats can be risks sources. In this stage the owners or the top managers can use e.g. brainstorming, Delphi Technique, structural talks and discussions with experts, questionnaires, internal audit, check list, etc. They can create so-called catalogues (registers) of risks that provide survey about possible risk factors or enterprises risks.
- Risk analysis the core of this stage is analysis of identified risks through the couple of criterions probability of risk occurrence and risk consequence. Mutual multiplying of criterions represents risk level. The first step includes elaboration of preliminary analysis to eliminate similar risks or risks of very small impact from the list of identified risks. But the eliminated risks have to be recorded to prove completeness of risk analysis. The second step includes elaboration of detailed risk analysis with use of specific methods. For SMEs is suitable especially qualitative analysis that enables to obtain general estimation of risk level. For selected risks SMEs can realize more specific quantitative analysis. For SMEs we recommend these methods, e.g.: expert risk assessment, crisis scenarios, sensibility analysis, FMEA, cause and effect analysis [12].
- Risk assessment the basic assumption of this stage is comparison of risk occurrence probability and risk impact

with defined criterions. Based on this comparison the risks are categorized in accordance with management priorities and the limit between acceptable and non-acceptable risks is defined. For easier categorization the risks can be indicated in risk matrix that increase visibility of risks and assist management decision making [11].

3. Risk treatment

The basis of this stage is proposal of measures only for nonacceptable risks that require developing special managerial plan together with financing of the respective proposal. Acceptable risks can be monitored for the reason of eventual future change of the level of identified risks. SMEs can non-acceptable risks:

- retain (risk retention), so to accept them in case of their low importance,
- reduce in two ways. Offensive approach says about reducing the probability of negative risks occurrence and is based on implementation of preventive measures. The measures should be specified for specific risks where it is possible to influence the events or factors having impact on the enterprise objectives. Defensive approach consists in reducing the importance of risks consequences and measures ex post. There are applied measures influencing risk impact that cannot be influenced by enterprise but also this risk cannot influence the enterprise objectives, e.g. increasing the prices of material or energies [9].
- use the form of transfer, e.g. insurance, concluding longterm sales agreement, leasing, factoring, etc.
- avoid (risk avoidance), this way is directly related to readiness of the owner to take a risk. We recommend it only in that case if the probability and importance of risk consequences are so high that they are not acceptable, e.g. business plan with high risk of failure, security and criminal risks, etc.

4. Monitoring and review

Monitoring and review is based on risks evidence. Each risk considered as critical should be recorded and related information passed to competent persons. As a tool of this evidence can be used, e.g. actualized risk catalogue, risk card containing file of standardly monitored data, report about risk that should be elaborated by responsible person always for specified date, etc.

5. Communication and consultation

Effective communication is important to ensure that persons responsible for implementation and carrying out risk management in the SMEs as well as aggrieved persons understood the decisions nature and reasons of need and importance of specific measures. Communication plan should be elaborated at the beginning of the risk management process.

4. CONCLUSIONS

SMEs represent in developed countries very important part of their economies and the same situation is also in Slovakia. Small and middle entrepreneur has very good conditions for risk management because he is closely connected with all aspects of the particular operations and knows a lot of strengths as well as weaknesses of his enterprise. Although the owners of the SMEs are intuitively aware of the common risk sources that influence their everyday life, it is a little probable that they will be aware such risk sources that they have no experience with. This fact implies the need of active and systematic work with risk that is included in the risk management process. For the SMEs it is necessary to know their risks especially due to their importance within the economic system of the Slovak Republic. They provide a large deal in number of working positions as well as in VAT.

Publication of this paper was supported by the European Union within the project No. 26110230079 Innovation and internationalization of education – tools of quality enhancement of the Zilina University in the European Education Area.

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Effect of normobaric hypoxia on psychomotor pilot performance

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Abstract - The diploma thesis deals with the effects of normobaric hypoxia on psychomotor performance of pilots. The aim was to create a model that could serve as a preselection of suitable candidates for training of commercial pilots. The methodology is based on a simple flight simulator that allows you to check the reaction time to unexpected events of probands with insufficient oxygen supply. The attention was paid to the description of existing knowledge of the problems and testing process itself, including evaluation of measured data. The results of measurement confirmed our assumptions, namely that is able to quickly and efficiently assess the suitability of candidates at minimum funds.

Keywords - Atmospheric pressure, hypobaric hypoxia, classification, oxygen, method, model, normobaric hypoxia, organism, proband, system, tension, test, pressure, hyperbaric chamber, Institute of Aviation Medicine in Prague.

INTRODUCTION

One of the most serious risk factors in aviation is the issue of hypoxia - a lack of oxygen in the blood, cells and tissues which may cause dysfunction or limited functionality. This dysfunction affects numerous biological functions in the foreground with the central nervous system, which is on the regular supply of oxygen entirely dependent. The result is a gradual degradation of logic and rational thinking and an overall reduction in performance. Therefore it is undeniable that hypoxia is very insidious condition and airline staff should have a good theoretical and practical knowledge about it. There is the issue of preventive and regular testing to the benefit of increased safety.

The aim of this study is to create a pre-selection test model, which can be used for clearly choose of ideal candidates to start training for the position of commercial pilot. An advantage is the relatively low cost of mentioned test thus can be used for regular control measurements of aviation personnel. Among other things, the study also could very well serve as an informative insight into the issue, leading to a form of awareness among the public, which is often distorted images.

PROBLEMS OF HYPOXIA AND OVERVIEW OF CURRENT KNOWLEDGE

The goal of this chapter is to describe accurately the issue of hypoxia, including all connections from the air psychophysiology, which are necessary for the understanding of this topic. However, priority was a good clarity of the whole text. It also includes a brief characterization of the Institute of Aviation Medicine in Prague and especially Flight Safety department which allowed all this research.

A. The physical properties


The first part is devoted to the physical properties of the atmosphere. In broader sense is the atmosphere working environment for the pilots. With increasing height are changing properties and thus effect of the atmosphere on function of the human body.

The chemical composition of the atmosphere is almost unchanged as a result of vertical mixing of air to an altitude of about 100 km. Given the nature of temperature changes occur to the vertical division into four basic layers, which are separated by 1 - 2 km strong transition layers.

Atmospheric pressure decreases with increasing altitude. The oxygen permanently occupies about 21% of the total gas content located in the air which is connected with proportional descent of partial oxygen pressure. Boundaries are constantly moving and therefore occurred a problem of decrease partial oxygen pressure in the atmosphere and lungs. The lack of oxygen negatively affected human performance, which was cause of much aviation disaster. Obviously, there were two possible solutions to this problem obviously:

- breathing of air enriched with oxygen during the flight. There is also the possibility to breathe pure oxygen, because with decreasing barometric pressure gradually decreases its toxicity to disappear completely,
- airtight cabin destined for people where will be



maintained normal barometric pressure.B. Institute of Aviation Medicine in Prague -Department of Flight Safety

Institute of Aviation Medicine in Prague is a specialized, diagnostic and therapeutic medical facility, which is only one in the Czech Republic authorized to issue certificates for staff aircraft. Specific procedures and medical examinations are carried out at the Department of flight safety. In the vacuum chambers are tested individuals exposed to different levels of vacuum, simulating stay at altitudes ranging from 0 to 13 000 meters above sea level. During testing are monitored physiological data reflecting the subsequent response of the human organism to changes in atmospheric pressure respectively the height. The exposure also serves as a

demonstration of the symptoms of altitude hypoxia and represents an important and unique practical experience increasing flight safety.

C. Hypoxia and its influence on the organism

With increasing height due to declining oxygen tension in atmospheric air is unprotected body influenced of decrease the partial pressure of oxygen in arterial blood. This specific type of inadequate supply of blood, cells and tissues by oxygen is called hypoxia, and the result is a gradual degradation of their functionality.

Type hypoxia	Characteristics and causes			
Hypoxic	The decrease in partial pressure of oxygen (piO2) at arterial blood in the drop in atmospheric pressure with increasing height Decrease in oxygen concentration in the inhaled mixture below 21 °% Faults of oxygen transport into the lungs (insufficient ventilation of the lungs, reducing airway patency, etc.)			
Anemic	Reduced ability of blood to carry oxygen due to:	Reducing the number of red blood cells Deterioration of haemoglobin in oxygen transport Decrease in haemoglobin concentration		
Stagnation	Own transport mechanism of oxygen is not disturbed seriously, however the blood supply to tissues stagnate as a result of:	Narrowing of the arterial bed (illness, injury) Heart failure and shock +Gz forces		
Histotoxic	The inability of tissues to utilize supplied oxygen and perform metabolism caused by:	Alcohol Some drugs Cyanide		

The study of the physiological effects of hypoxia began more than 100 years and at first sight it may seem that this issue is not a problem for aviation. The opposite is true despite a significant technical progress is hypoxia still one of the highest risk factors. The first significant signs of hypoxic condition are reflected in the decrease in the partial pressure of oxygen at 9,3 to 8,0 kPa, which corresponds approximately to a height between 3 000 - 4 000 m. For some of the less resistant individuals first defensive reactions can be observed at the border 2 500

m. Causes of lack of oxygen can be divided into three basic groups:

- reduction partial pressure of oxygen in the inhaled air,
- failure in a part of the oxygen transport mechanism,
- combination of both these causes when one can damage other parts of the oxygen transport mechanism.

Hypoxia affects the human body on several levels simultaneously. Each area of the human body react differently, and therefore it is necessary to pay close attention. Most affected are the following systems:

- nervous system,
- circulatory system,
- respiratory system.

An important term is the time of useful consciousness which precisely defines the maximal time interval in which the pilot is capable of rational and conscious thought.

Altitudo [m]	Time of useful consciousness - TUC			
Auuuue [m]	The Air	02		
5 500	20 - 30 min	unlimited		
7 500	3 - 5 min	unlimited		
9 000	45 - 90 s	unlimited		
10 600	30 - 60 s	6 min		
12 000	25 s	17 s		
13 000	5 - 15 s	seconds		
13 500	5 - 15 s	seconds		
15 000	5 - 15 s	seconds		

DESIGN OF MODEL AND TESTING METHODOLOGY

Hypoxic tests are important part of a complex testing of natural resistance towards fundamental risk factors emerging during flying. Demonstration effects of hypoxia in connection with central nervous system are realized through physiological tests based on simple mathematical operations and drawing tasks. The big advantage is simplicity but on the other hand it does not correspond to character of the flying pilot activities.

A. The final developed methodology

The aim of this work was to replace the mentioned tests. Solution is simple visualization system in which displayed a natural symbols associated with their spatial orientation for pilots. The basic premise for this system was to use the joystick (analogy with control of airplane) and computer with appropriate software, allows interactive control of the system, displays necessary elements and stores the results. The system was developed for the realistic simulation effects that occur in flight. Therefore pilots during hypoxic test react to two variable parameters and solve described tasks:

- move the joystick to correct the deviation of analogue pointer indicators,
- press a button integrated in the joystick to respond to stimuli displayed on a digital device.

B. Technical description of the device

A system for testing psychomotor function is located in a hypobaric chamber, however a hypoxic condition is achieved with a device that allows breathing air mixture containing reduced amount of oxygen without changing the atmospheric pressure hypoxic. The system is designed so that pilot controls joystick through which keeps the deflection of pointer at the marked position to simulate steady horizontal flight. Deflection of the meter pointer is realized by a pseudorandom signal. Except the joystick must tested person follow continuously changing the numerical value of numbers on the screen. On the basis of the individual assigned number must indicate by pressing the button on the joystick. The system continuously measures and retrieves deviation.



The entire test cycle consists of three five-minute stages, where each stage starts with one-minute tutorial interval and followed by a four-minute measured interval. Tutorial interval is used for familiar with the operation and prepare for measured attempt. The final outcome is evaluation of performance expressed as the integrated error in stage during and after hypoxia and mutual comparing of these results.

Throughout the duration of the test is a doctor present and closely follows screens of physiological system and response to psychomotor test of tested persons. In case of any serious complications test is prematurely terminated regardless to the importance of the measured data. The output of the program is the trend of integrated error compared with measurements in various stages.



ANALYSIS AND EVALUATION OF TESTS AND MEASUREMENTS

Whole test was carried out according to the described methodology. To verify predetermined hypotheses and thus confirm the goals, it was necessary to test the equipment at full load with a human crew.

Data stored on the disk are processed using the program and the output is represented by a table and graph. Both clear and unambiguous manner summarizes the course of the entire test and together with the record of biosignals physiological functions are guide in the final assessment of the specific resistance of the tested person to hypoxic effects.



Graphical output:





To test psychomotor performance during normobaric hypoxia was chosen set of individuals who could be potential applicants for the course of commercial pilot. Given this assumption, it was necessary to comply with two conditions:

- very good health (First class medical certificate),
- appropriate age.

Attribute	Value
Total number	22
Number of women	5
Number of men	17
The highest age	26
The lowest age	20
The average age	23,68
Standard deviation of age	1,55
Modus age	24
Median age	24

CONLUSION

The output of this study is the statistical evaluation, which was prepared on the basis of 22 tested individuals. The main objectives of this statistical analysis are:

- evaluate the effect of hypoxia on the testing role,
- evaluation of the statistical distribution of the calculated coefficient of influence of hypoxia,
- evaluate the correlation of physiological parameters (oxygen saturation and heart rate) in relation to the size of the integrated error, respectively the coefficient of influence of hypoxia.

The measurement results confirmed the assumptions and hypotheses. By using this method it is possible quickly and efficiently determines the effect of hypoxia on the psychometric performance of pilots at minimal financial resources. This can advantageously be used for:

- training of pilots with problems of hypoxia and its effect on the human body,
- testing of pilot resistance to manifestations of hypoxia may exclude individuals with extremely low natural resistance of flight training,
- testing the level of psychomotor performance affected by hypoxia with the possibility to quantify the potential effect of hypoxia on the allocation and distribution of attention,
- training of pilots in the early detection of this phenomenon and familiarity with the possibilities of preventive measures.

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Temperature and Relative Humidity forecasting based on Neuro-Fuzzy System

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ABSTRACT

The Temperature and relative humidity forecasting is the application of science and technology to predict the state of the temperature forecasts are made by collecting quantitative data about the current state of the atmosphere. This paper utilizes intelligence system for one step time interval ahead prediction of an important weather parameter which is temperature and relative humidity. Our study are forecasting temperature model based on Intelligence system such as Neural network and our proposed neuro-fuzzy which trained and tested using one year past(2010) weather data. We compared our forecasting model with another intelligence system. The results show that our proposed neuro-fuzzy has minimum forecasting error and can be considered as a good method for temperature and relative humidity forecasting. Thus, our proposed temperature and humidity forecasting model can be applied to calculating cooling load of building for energy management.

Keywords: Neuro-Fuzzy, Intelligence System, Forecasting Model, Nonlinear

1. INTRODUCTION

Current statistics on energy use in different sectors show that the building sectors use approximately 40% of the world's electricity supply, which is used for heating, air conditioning, ventilation, lighting, and the operation of various types of building services system equipment [1]. The figure is somewhat higher for building services systems operated in tropical or subtropical areas, where air conditioning accounts for at least 50% of a building's total energy consumption [2].

Generally, the main stream of energy analysis employs forward approach which the energy predictions are based on a physical description of the building system such as geometry, building construction details, HVAC equipment and operation schedule. However, the process of establishing the simulation model is very time-consuming and resource-intensive, especially for complex mixed-purpose buildings with unregulated operating schedules. Inverse modeling approach is another method relying on existing building parameters such as energy use, weather or any relevant performance data to identify a set of building parameters such as prediction of cooling load. Typically, regression analyses are employed to estimate the representative parameters for building and/or its systems using measured data. It is therefore apparent that an appropriate temperature and humidity control strategy is important to improve the energy efficiency of a building-HVAC integrated system, still guaranteeing thermal comfort conditions for building occupants [3].

Artificial Intelligence (AI) techniques are becoming popularly as an alternative approach to conventional approaches, particularly in inverse modeling approach. An

artificial neural network (ANN) can be used to approximate any nonlinear system and has the ability to adapt a complex environment via network training. Free of complex rules and mathematical routines, ANNs learn about the behavior of a complicated multidimensional system. In addition, ANN is fault tolerant, robust and noise immune [4, 5]. Therefore, the unique characteristics of ANN such as adaptability, nonlinearity, arbitrary function mapping ability, make them suitable for forecasting tasks among those AI techniques such as expert systems, genetic algorithms and fuzzy logic and is a good candidate handling the forecasting temperature data being inherently noise and incompletion [10 - 15]. A Neuro-Fuzzy system(NFs) is a combination of an adaptive neural network and a fuzzy inference system (FIS). The parameters of the fuzzy inference system are determined by the NN learning algorithms. Since this system is based on the FIS, reflecting amazing knowledge, an important aspect is that the system should be always interpretable in terms of fuzzy IF-THEN rules. Kisi [15] investigates the ability of Neuro-fuzzy for estimating daily dew point temperature. Results also indicated that the sunshine hours, wind speed, and saturation vapor pressure have little effect on dew point temperature. It was found that the dew point temperature could be successfully estimated by using T_{mean} and RH variables.

The main focus of this work has been to develop empirical equations of dry bulb temperature and relative humidity. This paper shows that property values predicted with NFs can be used to define the dry bulb temperature and relative humidity properties instead of approximate and complex analytic equations. So, the forecasting of temperature and relative humidity using NFs will be easier than using complex numerical iterative methods. In order to be useful, the method should be applicable to various substances, the accuracy given by the user should be achieved, and the resulting NF model should be fast in the simulation mode and practicable mode.

The paper is organized as follows: Section 2 presents the background about backpropagation neural networks (BNNs) and Neurofuzzy system (NFs). Section 3 presents the NFs model for forecasting temperature and humidity. A section 4 is devoted to experimental investigations and the evaluation of forecasting models from NNs and NFs. This section provides the basis for the selection of different variables used in the model, and the structure of model. The main conclusions of the work are presented in Section 5, with remarks on future directions.

2. NEURAL NETWORK AND NEUROFUZZY APPROACHES FOR THE TIME SERIES PREDICTION

2.1 Neural Networks (NNs) for Modeling and Identification

The neural networks are used for two main tasks: function

approximation and pattern classification. In function approximation, the neural network is trained to approximate a mapping between its inputs and outputs. Many neural network models have been proven as universal approximations, i.e. the network can approximate any continuous arbitrary function well. The pattern classification problem can be regarded as a specific case of the function approximation. The mapping is done from the input space to a finite number of output classes.

input layer hidden layer output layer



Fig 1 A feedforward neural network with one hidden layer [6]

For function approximation, a well-known model of NNs is a feed forward multi-layer neural network (MNN). It has one input layer, one output layer and a number of hidden layers between them. For illustration purposes, consider a MNN with one hidden layer (Figure 1). The input-layer neurons do not perform any computations. They merely distribute the inputs to the weights of the hidden layer. In the neurons of the hidden layer, first the weighted sum of the inputs is computed

$$z_{j} = \sum_{i=1}^{p} w_{ij}^{h} x_{i} = (W_{j}^{h})^{T} X_{i}, \quad j = 1, 2, \dots, m \quad (1)$$

It is then passed through a nonlinear *activation function*, such as the tangent hyperbolic:

$$v_{j} = \frac{1 - \exp(-2z_{j})}{1 + \exp(-2z_{j})}, \quad j = 1, 2, \dots, m$$
(2)

Other typical *activation functions* are the threshold function (hard limiter), the sigmoid function, and etc. The neurons in the output layer are linear, i.e., only compute the weighted sum of their inputs's computed:

$$yl = \sum_{j=1}^{n} w_{jl}^{o} v_{j} = (W_{l}^{o})^{T} X, \quad l = 1, 2, \dots, n$$
(3)

Training is the adaptation of weights in a multi-layer network such that the error between the desired output and the network output is minimized. A network with one hidden layer is sufficient for most approximation tasks. More layers can give a better fit, but the training time takes longer. Choosing the right number of neurons in the hidden layer is essential for a good result. Too few neurons give a poor fit, while too many neurons result in overtraining of the net (poor generalization of unseen data). A compromise is usually sought by trial and error methods.

The backpropagation algorithm [6] has emerged as one of the most widely used learning procedures for multi-layer networks. There are many variations of the backpropagation algorithm, several of which will be discussed in the next section. The simplest implementation of backpropagation learning updates the network weights and biases in the direction in which the performance function decreases most rapidly.

2.2 Neurofuzzy System (NFs) for Modeling and Identification

Both neural networks and the fuzzy system imitate human reasoning process. In fuzzy systems, relationships are represented explicitly in forms of if-then rules. In neural networks, the relations are not explicitly given, but are coded in designed networks and parameters. Neurofuzzy systems combine the semantic transparency of rule-based fuzzy systems with the learning capability of neural networks. Depending on the structure of if-then rules, two main types of fuzzy models are distinguished as mamdani (or linguistic) and takagi-sugeno models [7]. The mamdani model is typically used in knowledge-based (expert) systems, while the takagi-sugeno model is used in data-driven systems

In this paper, we consider only the Takagi - Sugeno-Kang (TSK) model. Takagi, Sugeno and Kang [7] formalized a systematic approach for generating fuzzy rules from an inputoutput data pairs. The fuzzy if-then rules, for the pure fuzzy inference system, are of the following form:

if
$$x_1$$
 is A_1 and x_2 is A_2 and x_N is A_N then $y = f(x)$ (4)

Where $x = [x_1, x_2, ..., x_N]^T$, $A_1, A_2, ..., A_N$ fuzzy sets are in the antecedent, while y is a crisp function in the consequent part. The function is a polynomial function of input variables $x_1, x_2, x_3, \dots, x_N$. The aggregated values of the membership function for the vector are assumed either in a form of the MIN operator or in the product form. The M fuzzy rules the form Eq. (4) are Ν membership in functions $\mu_1, \mu_2, \mu_3, \dots, \mu_N$. Each antecedent is followed by the consequent:

$$y_{i} = p_{i0} + \sum_{j=1}^{N} p_{ij} x_{j}$$
(5)

Where p_{ij} are the adjustable coefficients, for

 $i = 1, 2, 3, \dots, M$ and $j = 1, 2, 3, \dots, N$.

The first-order TSK fuzzy model could be expressed in a similar fashion. Consider an example with two rules:

if
$$x_1$$
 is A_{11} and x_2 is A_{21} and then $y_1 = p_{11}x_1 + p_{12}x_2 + p_{10}$
if x_1 is A_{12} and x_2 is A_{22} and then $y_2 = p_{21}x_1 + p_{22}x_2 + p_{20}x_3$

Figure 2 shows a network representation of those two rules. The node in the first layer computes the membership degree of the inputs in the antecedent fuzzy sets. The product node \prod in the second layer represent the antecedent connective (here the "and" operator). The normalization node N and the summation node \sum realize the fuzzy-mean operator. for which the corresponding network is given in Figure 2 Applying fuzzy singleton, a generalized bell function such as membership function and algebraic product aggregation of input variables, at the existence of M rules the neurofuzzy TSK system output signal upon excitation by the vector, are described by

$$y(x) = \frac{1}{\sum_{r=1}^{M} [\prod_{j=1}^{N} \mu_r(x_j)]} \times \sum_{k=1}^{M} \left(\left[\prod_{j=1}^{N} \mu_r(x_j) \left[p_{k0} + \sum_{j=1}^{N} p_{kj} x_j \right] \right) \right)$$
(6)



Fig.2 An example of a first-order TSK fuzzy model with two rules systems [7]

The adjusted parameters of the system are nonlinear parameters of bell function $(c_j^{(k)}, \sigma_j^{(k)}, b_j^{(k)})$, the fuzzifier functions and linear parameters (weight) of the TSK function for every j = 1, 2, ..., N and k = 1, 2, ..., M. In contrast to the mamdani fuzzy inference system, the TSK model generates a crisp output values instead of fuzzy ones. This network is simplified. Thus, the defuzzifier is not necessary. So, the learning of Neurofuzzy network, which adapts parameters of the bell shape membership functions $(c_j^{(k)}, \sigma_j^{(k)}, b_j^{(k)})$ and

consequent coefficients, p_{ij} can be done either in supervised

or self-organizing modes. In this study, we apply a hybrid method which is one-shot least-squares estimation of consequent parameters with iterative gradient-based optimization of membership functions. The important problem in the TSK network is to determine the number of rules that should be used in modeling data. More rules mean better representation of data processing, but increased of complexity of the network and a high cost of data processing. Therefore, the procedure for automatically determining number of rules is required. In our solution, each rule should be associated with one cluster of data. Fuzzy c-means is a supervised algorithm, because it is necessary to indicate how many clusters C to looks for. If C is not known beforehand, it is necessary to apply an unsupervised algorithm. Subtractive clustering is based on a measure of the density of data points in the feature space [7]. The idea is to find regions in the feature space with high densities of data points. The point with the highest number of neighbors is selected as center for a cluster. The data points within a prespecified, fuzzy radius are then removed (subtracted), and the algorithm looks for a new point having the highest number of neighbors. This process continues until all data points are examined.

In conclusion, Figure 3 summarizes the Neurofuzzy Networks System (NFs). Construction process data called "training data sets" can be used to construct Neurofuzzy systems. We do not need prior knowledge called "knowledge-based (expert) systems". In this way, the membership functions of input variables are designed by the subtractive clustering method. Fuzzy rules (including the associated parameters) are constructed from scratch by using numerical data. And the parameters of this model (the membership functions, consequent parameters) are then fine-tuned by process data.



Fig. 3 Constructing Neurofuzzy Networks

The advantage of the TSK fuzzy system is to provide a compact system. Therefore, some classical system identification methods, such as parameter estimation and order determination algorithms, could be developed to get the fuzzy inference rules by using input/output data. Similar to neural networks, Neurofuzzy systems are universal approximators. Therefore, the TSK fuzzy inference systems are general for many complex nonlinear practical problems, such as time series data.

3. METHODOLOGY FOR THE PREDICING OF TEMPERATURE AND HUMIDITY

3.1 Resource of History Temperature and Humidity Data

In this paper, Outdoor temperature, air relative humidity, wind speed and another properties recorded in previous time steps were used as predecessors to perform the forecasting dry bulb temperature and humidity. The wunderground website provides Web-based delivery of current and historical weather data, as well as weather-based tools and applications useful for decision making in agricultural production and natural resource management (additional information is available online at http://thai.wunderground.com/history/). Data from wunderground were used in this study was the history for Bangkok during 1 december 2011 to 31 march 2012. Some data was shown in Figure 4. And, Figure 5 shown some daily data used for our forecasting model such maximum temperature (upper line), mean temperature (middle line) and daily minimum temperature (lower line).

History for Bangkok (Suvarnabhumi),

วันศุกร์, เมษายน 1, 2011 — View Current Conditions

วันศุกร์, เมษายน 1, 2011		
« Previous Day	เมษายน	• 1 • 2011 •
Daily Weekly Monthly	Custom	
		Actual
Temperature		
Mean Temperature		28 เชลเชียส
Max Temperature		33 เชลเชียส
Min Temperature		24 เชลเชียส
Cooling Degree Dave		18

Fig. 4 Example of some temperature and humidity data in underground



Fig. 5 Example of daily temperature and humidity data in underground

3.2 The proposed NFs system for forecasting Temperature and Humidity Data

Based on the time series analysis, past information will affect the future. So, there should be some relationship between the weather data of today and the future. The relationship can be obtained through a group of mappings of constant time interval.

Assume that u_i represents today's weather data, y_i represents the weather data next days. If the prediction of a weather data after ten days could be obtained using today's weather data, then there should be a functional mapping u_i

to y_i , where

$$y_i = \Gamma_i(u_i) \,. \tag{7}$$

Using all (u_i, y_i) pairs of historical data, a general function Γ () which consists of Γ_i () could be obtained.

$$y = \Gamma(u) . \tag{8}$$

More generally, \vec{u} which consists of more information in today's price could be used in function Γ (). NNs and NFS can simulate all kinds of functions, so they also can be used to simulate this Γ () function. The \vec{u} is used as the inputs to the intelligence system.

It is important to mention, that forecasting model is based on the idea of sliding window. The size of sliding window shows how many times the cycle of the model has to be run in order to get the decision. For each day's prediction a new sliding window is needed. An example of sliding window is presented in Figure 9. As it can be seen from the presented picture, sliding window represents the training part of each time interval. For the training of NFs there is used the optimizing algorithm which is selecting a number of membership function and fuzziness parameter for NFs model. At first, the best NFs of the day is selected. The best NFs is called that NFs which have shown the best performance (the highest total profit for the selected sliding window).

This paper attempts to build a collaborative forecasting model to detect daily weather signal. The system of collaborative forecasting model developed from computational intelligent approach to learning overall weather signal knowledge and dynamic threshold knowledge. We proposed

NFs for the prediction system, called intelligence trading system. Our proposed model was shown in Figure 7.



Fig. 6 Sliding window of training and testing data (one day).



Fig. 7 The scenario of NFs model for forecasting Temperature and Humidity Data

In summary, input of NFs were combined with n period of temperature, dewpoint temperature and relative humidity on previous day. And, Output of NFs is 2 outputs which are temperature and relative humidity on present day. From figure 7,

T-1 is 1 previous day of dry bulb temperature T-2 is 2 previous day of dry bulb temperature T-3 is 3 previous day of dry bulb temperature is n previous day of dry bulb temperature T-n Tdp-1 is 1 previous day of dew point temperature Tdp-2 is 2 previous day of dew point temperature Tdp-3 is 3 previous day of dew point temperature Tdp-n is n previous day of dew point temperature RH-1 is 1 previous day of relative humidity RH-2 is 2 previous day of relative humidity RH-3 is 3 previous day of relative humidity RH-n is n previous day of relative humidity

3.3 Preprocessing of input and Evaluating Function for the proposed NFs Model

In general, the weather properties data have bias due to differences in name and spans. Normalization can be used to reduce the range of the data set to values appropriate for inputs to the activation function being used. The normalization and scaling formula is

$$y = \frac{2x - (\max + \min)}{(\max - \min)},$$
(9)

Where

x is the data before normalizing,

y is the data after normalizing.

Basically, each of thermodynamic properties are not same scale. Thus, Normalization use to individual for any thermodynamic properties, so the same maximum and minimum data are used to normalize them. The max is derived from the maximum value of the any properties, and the same applies to the minimum. The maximum and minimum values are from the training and validation data sets. The outputs of the NFs and NN will be rescaled back to the original value according to the same formula.

There are several kinds of error function used in evaluating of approximating method, namely, Mean absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE). In this paper, like a neural network model, we used two error functions for our NFs system; the Percentile Variance Accounted For (VAF) [9] is selected for evaluating the NFs model. The VAF of two equal signals is 100%. If the signals differ, the VAF is lower. When y1 and y2 are matrices, VAF is calculated for each column. The VAF index is often used to assess the quality of a model by comparing the true output and the output of the model. The VAF between two signals is defined as follows:

$$VAF = 100\% * [1 - \frac{var(y1 - y2)}{var(y1)}]$$
(10)

4. RESULTS AND DISCUSSIONS

All the experimental investigations were run according to the above presented scenario and were focused on the accuracy within 99% VAF for training sets and 90% VAF for testing sets. At the beginning of each realization, the data set was including in dry bulb temperature, dewpoint temperature and relative humidity. The weather data is from January 1, 2011 to April 30, 2012 totaling 486 records. The first 438 records are training data, and the rest of the data, i.e., 48 records, will be test data.. Consequently, max-min normalization can be used to reduce the range of the data set to appropriate values for inputs and output used in the training and testing method.

For input data, we proposed 3 input models. Firstly, model 1 was totally 15 inputs such as previous temperature, dew point and relative humidity on 5 previous day. Secondly, model 2 was totally 30 inputs such as previous temperature, dew point and relative humidity on 10 previous day. And thirdly, model 3 was totally 60 inputs such as previous temperature, dew point and relative humidity on 20 previous day. For example as shown in Table 1,

Table1 Input and output variables in 1st forecasting model



We now compare the performance of our proposed neurofuzzy system to feedforward Neural Network Modeling

including three types of learning algorithm methods. Their learning method are Batch Gradient Descent (TRAINGD), Scaled Conjugate Gradient (TRAINSCG) and Levenberg – Marquardt (TRAINLM) methods The neural network model has one hidden layer with 20 nodes. And, learning iteration is 10000 epochs. After trained their learning method, we found scaled conjugate better than other learning method. But, we can conclude that our proposed neurofuzzy demonstrated a considerably better four relation types than neural network with scaled conjugate gradient learning.



Fig. 10 Forecasted Temperature based on Neuro-Fuzzy (dash line) v.s. real temperature (solid line) on Trained Sets



Fig. 11 Forecasted Temperature based on Neuro-Fuzzy (dash line) v.s. real temperature (solid line) on Tested Sets







Fig. 12 Forecasted Relative Humidity based on Neuro-Fuzzy (dash line) v.s. real Humidity (solid line) on Tested Sets

<u>Table2</u> Experimental Result of various forecasting models based on NN and NFs

Algorithm	Input	Output	Node	RMS		VAF	
				Train	Test	Train	Test
NN-LM	5	1	10	0.0618	1.5071	94.219	7.870
NN-SCG	5	1	10	0.1307	0.3362	75.890	40.893
ANFIS	5	1	3	0.1357	0.3752	74.015	17.957
NFs	5	1	20	0.1199	0.3474	79.737	19.569
NN-LM	10	1	10	0.0213	0.0570	99.500	97.518
NN-SCG	10	1	10	0.0308	0.1144	98.657	90.085
ANFIS	10	1	3	1.81e-7	2.01e-6	100.00	100.00
NFs	10	1	20	2.07e-16	3.19e-16	100.00	100.00
NN-LM	20	1	10	0.0318	1.2121	95.412	10.458
NN-SCG	20	1	10	0.1111	0.2331	80.123	50.458
ANFIS	20	1	3	0.1257	0.3542	78.123	18.123
NFs	20	1	20	5.12e-10	12.887	100.00	0.602

From Table 2 when comparing of 3 Models, The result of RMS and VAF from Model 2 is better than Model 1 and 3 on testing set. Thus, 10 previous day was suitable for prediction both dry bulb temperature and relative humidity. In model 2 of testing set, NN was accuracy in 97.518 % VAF and NF was accuracy in 100 % VAF.

The comparisons of different models such as BPN and the TSK fuzzy rule model are listed in Table 2. As we can observe here, the modeled results from TSK fuzzy rule model are much better than those from BPN or multiple regressions which justify the TSK fuzzy rule model is the best. The all results exhibit that Backpropagation Neural Networks (BNNs) and Neurofuzzy System (NFs) can be model several thermodynamic properties satisfactory as a new method instead of approximate and complex analytic equation.

5. CONCLUSION

A novel method for the forecasting of dry bulb temperature and relative humidity was developed. The desired outputs are accuracy within 100% VAF for training sets and 100% VAF for testing sets, respectively. From experimental results, our proposed model is achieved in every testing data. Both of intelligence systems, which are BNNs and NFs, were successful in the training and testing data. But, NFs always was accuracy than BNNs. Moreover, NFs model was proved to be faster and accuracy than BNN and the conventional iterative algorithm used for generation of the training and testing data sets. An advantage in using the NFs model is applied to calculating Enthalpy of boiler, turbine, condenser and cooling tower in real compact power plant. With Real-time Enthalpy, the software was monitoring, controlling and calculating efficiency of the experimental mini steam power plant.

The developed procedure can probably adapt for the description of thermodynamic and other material properties of several substances. By using the NFs, the approximations previously requiring several iterations for solving complicated function is reduced to a single function call.

8. ACKNOWLEDGMENT

I would like to thank participants for their helpful comments and invaluable discussions with them. This piece of work was partly under in kind and financial support from Faculty of Engineering and Center of Innovative Mechatronics and Robotics (IMERs) at Department of Mechanical Engineering (Kampangsean), Faculty of Engineering (Kampangsean), Kasetsart University (Kampangsean), Nakhonpatom, Thailand.

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Improving Real time Motor Skills in Physical Education by Virtual Computerized Technology Training

A Successful Attempt at Teaching Novice Computer Users

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ABSTRACT

The present research is aimed at improving real time motor skills by physical education MA students through virtual computerized technology training. This is done by using unique simulated virtual computerized tools.

Each student executed action research in his/her physical education lessons. The main principle of the students' action research is applying the virtual computerized technology environment to the real time motor skills up to functioning successfully in physical education lessons without using computers. while controlling 2D and 3D space. The researcher taught this method to 56 MA students majoring in physical education. Such procedures were held among va/ious populations. The findings showed that as the virtual computerized technology training increased the pupils' real time motor skills were gradually improved and their confidence in performing such activities was enhanced.

The students' awareness of this important impact was also enhanced.

The virtual computerized training contributed to the cognitive thinking and to the cumulative knowledge enrichment in future experiences. In such a way, the knowledge impacts thinking development in future situations.

Moreover, the students were able to translate theory into their everyday teaching and raised the level of their academic writing as well.

Keywords: Action Research, Cognitive sciences, Computerized Technology, Knowledge, Motor Skills, Real Time, Virtual.

1. INTRODUCTION

Concerning the present study, owing to the fact that scientists and teachers are not aware of the virtual computerized technology training's impact on real time motor skills that seemingly are contradictory to each other, they reject the whole idea out of hand claiming the whole thing is utterly absurd. In this framework we are checking the possibility to proceed from the virtual computerized technology environment to the real time motor activities.

The network is able to reproduce recorded creative learning processes by means of simulation (1). For coaching learning and practice to be realistic and sustainable, teachers need to become more aware of their relationship with pupils as knowledge generators and active participants in their own learning workplace (2) (3). Developing control over reality and compatibility with the everyday environment occurs as a result of manipulating virtual computerized technology environment.

2. THEORETICAL REVIEW

The term "virtual" is popular among computer scientists and is used in a wide variety of situations. The opposite of virtual is real, absolute or physical (4).

According to Merians (5) and Reid (6), "virtual technologies can be used to produce environments in which intensity of practice and feedback on performance can be manipulated to provide tailored motor training."

The purpose of an accurate physical model of a complex environment, real time response, and a natural user interface is to provide multiple scenarios to players at different levels of difficulty (7).

In order to understand the inter relationships between cognition, knowledge and the achievements gained through the virtual computerized technology training, it is required to interpret the connection between cognition and knowledge in theoretical studies. This connection is deeply studied by Callaos (8), as the "cognition generates knowledge via sense data, information, perception, inference, interpretation, analogical thinking, imagination... etc", and "previously acquired knowledge ... supports and shapes cognitive processes, and ... influence other related mental processes and affect which in turn ... orient, propels or inhibit cognitive processes". The main domains included in the cognitive sciences and related to the present research are cognitive psychology and artificial intelligence. According to Goldman (9) human knowledge... must work hand in hand with cognitive science. "The great benefit of knowledge and cognitive sciences for sport will be that knowledge and expertise in world class sport will trickle down to mass level that in turn will supply the elite with access to new talents and ideas (10). Science has contributed considerably to the knowledge and understanding of racket sports, and racket sports have contributed to science by providing unique challenges to researchers (11).

The knowledge-based approach has been labeled as a significant conceptual framework in adapted physical activity research (12) and it was linked to the inhibitory model of executive functions (13) because the latter grand theory describes the complexities of self-regulatory behaviors, with specific reference to ADHD. Taking necessary time to reflect on the purpose and outcomes of movement skills, which may be difficult for some children with ADHD and children with movement difficulties (14) (15), is related to an awareness of the important meta-cognitive skills of error deduction, planning, and monitoring of actions (16). Since the impact of virtual computerized technology training on physical education still seems unlikely, we selected the Tetris software to show this impact by improving ADD/ADHD pupils' various motor skills. Doctors, pilots, and astronauts routinely use virtual computerized technology to learn new skills, and to perfect those they already have (17). We have not found yet other researchers dealing with the impact of practicing Tetris software on improving ADD/ADHD pupils' real time motor skills in physical education lessons.

Buderath et al. (18) found that children with ADHD had dynamic balance problems when they had to rely solely on vestibular information (without visual and proprioceptive information). These children performed similarly to children with cerebellar lesions, supporting the idea that ADHD may be associated with some cerebellar dysfunction associated with balance problems. According to these findings, such populations may have difficulty functioning in physical education classes.

The Virtual Computerized Technology Software as A Mediator between Symbolic and Concrete Actions

Pazhitnov (19) invented the Tetris game in 1985. Since then, this computer game has been considered the most challenging in solving problems rapidly. It requires manipulating virtually while the users race to fit falling blocks together on the screen. In the game, the player sees the objects graphically and tries to organize them before they fall (20). It links the concrete and the symbolic by means of feedback. The manipulations of the shapes over the computer screen (rotating them to the right or to the left side) link the symbolic commands to a sensory-concrete turning action (21). The game exploded in popularity after the Nintendo Co. and other people put it on their popular game machines.

In the last few years, many more such computer software have been produced, but the Tetris computer software is more readily available and it also better illustrates the impact of virtual simulations on real time motor skills.

Wii Sports provided children with disabilities with chances to play sports just like children without disabilities (22). The Vrtual golf game involves hitting computer-generated golf balls by swinging a real club. Watching to see where the ball goes on the simulated golf course that is displayed on the screen, players can monitor the distance and accuracy of each shot and work on making their swing better (23).

The technology enables presentation of information in threedimensional formats in real time (24) (25) (26). Situations which are too complicated to perceive in a real time learning environment can be presented and viewed in many different perspectives in a virtual computerized technology environment (25) (27). Such an environment can provide the opportunity to repeatedly practice a skill without the fear of injury or embarrassment. The reported effects on children include: gaining a new perspective (28), increasing participation and access (27) (28), instilling a sense of confidence, competence, self-control and mastery (24) (28).

3. RESEARCH PRESENTATION

Procedure

The research group was composed of 56 MA students majoring in physical education. The tests were conducted for 2 meetings per pupil, a total of 30 minutes per pupil before and after the intervention program, which lasted eight weeks, twice a week. This was a pilot research.

The Research Method

The students planned their study and reported on each stage they completed.

The Main Stages of Instruction

We took longitudinal research as our model (29) during one semester (3 months) and included four stages:

Stage 1: Learning the rationale of improving real time motor skills in physical education by virtual computerized technology training.

Stage 2: Planning research:

- Choosing a pupil diagnosed with ADD/ADHD.
- Testing the achievements in the examined skills
- Building and performing virtual activities.
- Explaining the rational of simulative software and training it.

Stage 3: Retesting the achievements in the examined skills.

Stage 4: Writing the action research report.

The student writes his/her analysis using a professional PowerPoint presentation, and relates the practice to the theory. **Research Tools**

Spatial Intelligence Test: Standard Progressive Matrices test of Raven (30).

Ball dribbling and also walking on marked path while dribbling along the cone course.

Media

PowerPoint software was used for writing the action research report.

The computer "Tetris Game" software was used to test spatial skills and improve motor skills. The players aimed at filling 2D shapes into rows and a large 3D cube with small blocks of different shapes. During the use of the Tetris task, block-shaped pieces appear at the top of the screen and fall down, while players manipulate them, so that they fit into point-scoring rows. In order to attain a high score, the users need to act both precisely and rapidly. The users have to complete the blank locations on the board according to an inferred rule and fit the appropriate shape in the blank locations.

The Tetris software is characterized by the following:

1. Each form appears in the upper part of the game board and is going down at a constant speed.

2. The degrees of difficulty are determined by the speed at which the forms move down.

3. At any time when the line or the surface in the three dimensional Tetris game is filled, it is erased and the participant scores points.

The keys for enacting the "Tetris" software are the same: The user can move the form to the right or to the left side, or take it down by using the arrow-keys. The form can be rotated to fit the empty space to be filled by using the space bar, 90^{0} to the right or to the left.

The use of the "Tetris" software serves as a technologic mean for testing and training spatial orientation and visualization, motor skills, hand-eye coordination, and time orientation. Such testing and training intend to examine and prepare the learners for their effective spatial functioning in real time.

The students built and used a PowerPoint presentation that exemplifies the dribbling action while the pupils are active participants by pressing on the computer mouse for any action over the computer screen. This presentation is built in such a way that every click on the mouse causes a ball to bounce on the screen.

Examples of the action research done by the students focusing on training virtual computerized technology and testing real time motor skills.

Case Presentations (Pre-intervention and intervention)

Description of the intervention program

- Choosing a child diagnosed as having ADD/ADHD.
- Constructing a dribbling test:
 - Checking the pupils' dribbling ability on a basketball court: First task: dribbling in place, once with the pupil's
 - strong hand and once with the pupil's weak hand.
 Second task: Dribbling while walking forward and
 - then walking backward.
 - Third task: dribbling on a marked course.
 - Building and Training the PowerPoint presentation.
 The pupil gets an explanation before enacting the presentation.
- Rechecking the pupils' dribbling ability on a basketball court (The third task):
- Testing the completion of non-virtual matrix shapes in space.
- Training space control using virtual simulation software.
- Rechecking the pupils' dribbling ability on a basketball court (The third task):
- Testing the completion of non-virtual matrix shapes in space.

Case No. 1:

Bashari's project (31) was aimed at investigating spatial and dribbling skills of regular ADD 9-year-old 3rd grader. She still has not gotten medical therapy.

Overall aim: to improve an ADD child's walking on a marked path while dribbling a ball with her right hand and to improve her level of attention and focus in physical education treatment. Secondary aim: to raise her motivation and the level of her self-Esteem, self-perception, self-confidence, confidence in the environment, and diligence in carrying out her tasks.

The pupil was asked to dribble while looking at the area around her in order to be able to make detours around the cones.

The pupil failed to complete the 10-meter exercise without losing the ball several times. The pupil felt she could not do both things simultaneously

The pupil accepted the challenge. She stood very near the cones and began to dribble, but she was unable to move between them. When she got near the cones, she lost the ball and was unable to continue.

Case No. 2

Gross's project (32). The subject was a young woman 20-yearold with average mental retardation, suffering from attention and focus issues. She learned at a school of special education.

She dribbled with her right hand, but the quality of her movements was bad. She would use maximum strength to bounce the ball, and the ball would bounce too high to control. She would try to regain control of the ball and start all over again. She had difficulty differentiating movements and her mouth and tongue movements tended to be slow and heavy. She was not aware of her surroundings when exercising.

Overall aim: to improve this ADHD pupil's physical performance and behavior in her physical education lessons. Secondary aim: to raise the pupil's motivation, self-perception, self-confidence and diligence in carrying out her tasks

At the beginning of trainig Tetris, the pupil had great difficulty since she could not understand that she could turn the shape on the screen a few times in order to get the desired result. Repeating the test, she could dribble near the cones, but could not move between them. Every time the student worked with the pupil, she would ask her in the hall of the school if they would dribble the ball on that day or if she had the Tetris.

Evaluation

Evaluations were made on comparing the level of:

- The students' writing of the action research and planning the teaching program.
- The pupils' motor achievements before and after both kinds of the training.
- The pupils' simulative software average scores.
- The pupils' score in the Raven's matrices test.

4. FINDINGS

The findings show an improvement in the pupils' achievements in all the capabilities we checked: dribbling ability along the cone course, including 2D and 3D space-related skills. In addition, the MA students that participated in the study are more aware of the connection between the theoretical-scientific approach they used in their action research and its application.

The research showed that the students' reports became then clearer and more detailed as well (See table no. 1).

Furthermore, the motivation and self-confidence of the MA students and pupils were enhanced.

Table No. 1: Example of Differences between the Level of Research Performance of the Students at the Beginning and the End of the Course

Start of Course	End of Course
Focusing exclusively on theory.	Applying the theory to the teaching work.
Editing the research, in general, without using authentic examples.	Editing the research according to the standards. Using examples taken from the virtual and non-virtual spatial and motor activities.
Writing long, complex sentences related to one motor skills only.	Writing brief, structured sentences, focusing on real time motor skills and virtual computerized technology training.
Copying the articles' text.	Writing the text in their own words.
Focusing on some objectives. Having difficulty differentiating between main and sub objectives. Having difficulty formulating the assumptions.	Focusing on the main objectives and assumptions.
Mixing results and discussion. Misunderstanding the impact of using virtual computerized technology on real time motor skills.	Differentiating between results and discussion, Summarizing briefly each table showing the results. Then concentrating on the discussion, analyzing the results according to theory. Emphasizing the impact of the virtual computerized technology training on the real time motor skills in physical education.

All the MA students succeeded in their studies, while their pupils achieved high scores in the post-intervention tests, relatively to those in the pre-intervention tests.

The students' academic reports relating their pupils' improvement strengthen the cases described in this article and also the rest of the MA group's projects.

We might highlight the progress noted among the students by demonstrating each one of the projects that they performed.

Case Presentations (Post-intervention)

The data displayed in tables no. 2, 3 4, 5, 6 and 7 show an improvement in the pupils' performance in all examined skills.

Case No. 1: Bashari's (31).

Virtual Computerized Technology Training

While using the Tetris software the pupil reached the ability to look not only at playing board, but also at her immediate general surroundings. On the right-hand side of the screen there is a square marked with the word "NEXT," which presents the following shape.

The pupil was able to bridge large gaps in her last attempts working with the software.

Real Time Motor Skills

After the intervention program, the pupil reached her goal. She was able to dribble the ball in a straight line for five meters.

"After repeating the Tetris software, we made the transition to the dribbling course with the cones. It was amazing to see the rapid change that took place in the pupil. She was able to complete the dribbling task very easily without losing the ball while looking at her surroundings all the time".

Table No.	2:	Pupil's	Average	Scores	in	Using	Tetris	during	the
Interventio	on								

The level	Intervention			
	No. of lines	No. of points		
Level 1	1 line	170		
	1 line	100		
	2 lines	260		
	3 lines.	300		
	2 lines	250		
	3 lines.	320		
Level 1	6 lines	820		
	7 lines	800		
Level 2	0 lines	1430		

The findings in table no. 2 show an additional improvement in the pupil's average scores in the Tetris training trials.

Table No. 3: Pupil's Scores in the Raven's Matrices Test before and after the Intervention

The level	Pre-Intervention	Post-Intervention
	Score in %	Score in %
Level 1	74.47	85.11

The findings in table no. 3 show an improvement in the pupil's scores in the Raven's Matrices post-intervention's test.

Table No	$4 \cdot \text{The}$	Punil's	Level in	Dribbling	and Slalon
	4. 110	FUDIIS	Level III	DITUDITING	and Staton

Table 1(0: 4: The Tuph's Eever in Dilboning and Statom						
Pre-	After Experiencing	Post-Intervention,				
Intervention	Power Point	After training Tetris				
	presentation	Software				
Cannot dribble	The pupil failed to	Is able to dribble 10				
in the course	complete the 10-	times for 5 meters				
uninterruptedly	meter exercise	without fumbling				
for 3 meters	without losing the	the ball,				
without	ball several times.					
fumbling the	She felt she could					
ball.	not do both things,					
	dribbling technique					
	and raising one's					
	head to look at the					
	playing					
	environment,					
	simultaneously.					

The post intervention data in table no. 4 show the pupil's improvement in dribbling.

Case No. 2: Gross's case (32) **Virtual Computerized Technology Training**

The pupil's scores improved from 0 to 860 points.

Real Time Motor Skills

The pupil was able to perform 7 dribbles uninterruptedly in a straight 2-meter-long line. After the intervention period she was able to reach her goal: she could dribble the ball in a straight line for 5 meters. The pupil would ask the student at every opportunity in the school hall if on that day they would use the ball or if she had brought the Tetris software.

Table No. 5: Pupil's Average Scores in Using Tetris before and after the Intervention

The Level	Intervention			
	No. of Lines	No. of Points		
Level 1	0 line	0		
	1 line	110		
	2 lines	210		
Level 1	2 lines	230		
	5 lines	860		

The findings in table no. 5 show an additional improvement in the pupil's, average scores in the Tetris training especially in the second trial.

Tabl	e No. 6:	Pupil's	Scores	in the	Raven's	Matrices	Test be	efore
and	after the	Interver	ntion					

The level	Pre-Intervention	Post-Intervention
	Score in %	Score in %
Level 1	50	65

The findings in table no. 6 show an improvement in the pupil's scores in Raven's Matrices post-intervention test.

Table No.	7:	The Pupil's	Level in	Dribbling	and Slalom

		*
Pre-Intervention	After experiencing	Post-Intervention,
	Power Point	after training Tetris
	presentation	Software
Can dribble	The subject was	Is able to dribble in
2-3 times	able to perform 7	the course for
uninterruptedly,	dribbles	approximately 10
unable to make	uninterruptedly in a	meters without
progress, with	straight 2-meter-	fumbling the ball.
low quality	long line.	
movement		

The post intervention data in table no. 7 show the pupil's improvement in dribbling.

Main Changes in the MA Students

- Understanding that the virtual computerized technology training contributes to the transfer in learning process which leads the pupils to perform the required physical activities without additional computerized training.
- Understanding the impact of virtual computerized technology training on knowledge and cognitive thinking.
- Improving their academic writing.

The Students' Feedback:

"At the outset, we were very skeptical about the hypothesis whether computer games could really enhance sports skills of children. Although during the experiment we read articles and research on the subject and found out that there is a strong connection between physical activity and improving motor skills, and exercising with didactical computer games, we still found hard to believe that this could be true."

According to the student in case 1, there was a qualitative change in the improvement of motor skills. She added, "I have decided to look into the problem in depth. I read articles, research and books. In the end, I decided to take the pupil for tests. The results showed she had ADD." She concluded by

emphasizing: "The course as enlightening. I learned a lot on the subject in general as well as how to approach children with learning disabilities in different ways and teach them at their level – to search what additional motor skills to teach them through games. Thanks to the project, I re-discovered the pupil. I knew she was smart, but now I see how intelligent she really is and how motivated she is to learn everything. There were items in the matrix test that she was able to answer correctly, but teachers could not. I formed stronger ties with her and got a deep understanding. We are now continuing with additional projects."

The student working in case 2 noted that in light of her work, she sensed how working with a computer and didactical games can enhance motor skills. *She teaches therapeutic sports, especially with special children. For her, every willful movement a child does is another small step to success.*

She concluded by emphasizing: "Through this project I strengthened my convictions that things are not irreversible, but cognitive activities and interactive games can have an impact on motor skills, so that they have a mutual impact.

I see your research in this area as a breakthrough in understanding children's disabilities and accessing them to children with special needs, especially in the domain closer to us – physical education."

The Main Progress of the Pupils in their Learning Process

- The virtual computerized technology training changed their learning gradually from 1 or 2 to 3 dimensional spatial intelligence level and important for the pupils' real time motor skills.
- The examined technological and motor skills improved.

The Pupils' Feedback

Case 1

After checking the motor skills and using the Tetris simulative software, the pupil became enthusiastic about her success, happy that the student working with her had insisted that she perform all the tasks to the end. She showed everybody how she was able to perform the tasks she had experienced without fumbling the ball, asking the student "what are we going to do next time?"

Case 2

The pupil sometimes asked to work with us at unsuitable hours. When the student informed her of the proper time they would work together, the pupil would insist on meeting immediately. Following the meetings, the pupil would immediately begin to impatiently wait for the next meeting.

She enjoyed the Tetris simulative software the most. She approached dribbling with a lot of energy, and when she began to improve her skills, she would give out a shout of triumph.

5. DISCUSSION

The questions raised in this research are how can virtual computerized technology training improve real time motor skills and what is the contribution of this improvement to the knowledge and cognitive thinking. In spite of the short time of training and the absence of experience in using technological means such as computers before training, a significant improvement was recorded, as a result of the original, innovative and creative mode of learning.

The virtual computerized technology training enables the students and pupils to perform activities that are not available in real time (33). Real time motor skills refer to immediately and actually performed activities rather than virtual computerized ones. This definition is the present research insight.

The virtual computerized technology training included experiencing PowerPoint Presentation and training Tetris software. The results showed an improvement after experiencing PowerPoint Presentation. This improvement increased after training the Tetris software. It will be interesting to investigate a group who uses the PowerPoint presentation versus the other group that will not use the presentation in order to examine the presentation's contribution to the improvement in real time motor skills.

The Impact of the Virtual Computerized Technology Training on the Real time Motor Skills

The third dimension helps giving game players a sense of "presence" in the game. (34). "As digital worlds become more immersive, there is greater potential for the gamer to live in the virtual world, that is the most important reality" according to Cohen &Taylor (35). These researchers suggest that sport media studies need to expand its theoretical and empirical practice away from the focus on texts to a focus on the phenomenology of gaming and sport (36).

The Uniqueness of the Method

The findings emphasize the available transfer from the virtual computerized technology training to better functioning in real time motor activities in the gym or field without computers. The students can also create accessible computerized activities.

Users of the virtual Tetris software may elect to preview each upcoming shape in order to plan the next step in using the software while manipulating the fast-changing environment over the computer screen. The same skill is needed for performing motor skills, especially dribbling along the course without fumbelling the ball. The student who worked in case 2, Gross (32) offered to continue to investigate the connection between organizing for the dribbling activity on the cones course and additional kinds of simulated software.

Such research enables the MA students to:

- Translate theoretical concepts into practical language,
- Apply them during their teaching practice in a physical education classes, and
- Interpret the results of the experiences by looking at them through the perspective of the theoretical approaches he/she has applied. Such courses usually focus on the basics of the use of computers only.

The matrices require cognitive thinking and thinking analysis by completing the next sequence or matrix. The cognition is similar to cognitive thinking in which the subject is required to try on the basis of given situations.

Virtual computerized technology training exemplifies the effects of the manipulation of forms moving rapidly on the computer screen. The students succeeded in applying physical education theory in their teaching work through the PowerPoint presentation and software, initiated by their need to understand the conception regarding the impact of virtual computerized technology training on their practical success.

6. SUMMARY AND CONCLUSIONS

This study, first and foremost, examined the real time motor skills improvement in physical education as a function of virtual computerized technology training According to the MA students, before the intervention in their practical work, they had great doubts that any impact of virtual computerized technology existed on physical education in a gym or a sports field. However, during the intervention itself and especially after looking at the results, they were convinced of the existence of such an impact. Consequently, they recommended to other students to take the course. As everyone knows, it is highly unusual to see computers in a gym or on a sports field. The contribution of the research in this context becomes clearer as the simulated real time related space becomes available even in none-computerized environment. Usually teachers teach knowledge and cognition that contribute to the training. But in the present research we can see the opposite situation where the computerized concrete operations impact the cognitive thinking and enrich the knowledge.

It is also very important to note the fact that the research is also evident in the integration of theory and practice in the framework of the students' action research as reflected in their academic papers (37).

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Zooming In, Zooming Out: A Framework for Hierarchical Genetic Algorithms

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Abstract

We present a framework of algorithms and techniques involving hierarchical genetic algorithms. These algorithms attempt to generate models and solutions at both the structural and atomic levels simultaneously using atomic and global chromosomes. Complex adaptive emergent systems of comprised heterogeneous, (CAESs) are interacting, adaptive agents that exhibit the properties of self-organization, emergence, and connectivity [Ahmed2005]. This paper presents early work and is meant to serve as a starting point in the synthesis of complex adaptive emergent systems using HGAs. Two implementations are discussed¹ that exemplify the compositional nature of hierarchical genetic algorithms and their applicability to both modeling and iteratively generating complex adaptive emergent systems.

Introduction

A Hierarchical Genetic Algorithm (HGA) is an algorithmic technique of artificial intelligence that converges on a solution at both the atomic and structural levels. Complex adaptive and emergent systems (CAESs) are ubiquitous in our worldappearing as beehives, to social systems, to the brains in our heads that contemplate them. The modeling techniques used for understanding and predicting behavior of these systems in the past been ordinary differential equations, cellular automata, evolutionary game theory, agent based models, and networks [Ahmed2005]. Because of their implicit nested structure, self-organizing and iterative nature, however, we contend that HGAs show great promise to provide an alternative method of modeling CAESs. Moreover, by using HGA's to intentionally generate systemic

simulations of CAESs, we expect to gain insight as to how CAESs are triggered, internally controlled, and sustained.

The work presented here includes the author's taxonomy of techniques based on the nesting of chromosomes and of the overarching *generate-measure-select* algorithm canonical to genetic algorithms. Two computer systems from recent work are discussed in the context of the framework presented here.

Background and Basics

The thrust of this work lies in the simultaneous evolution of a solution at two different abstraction layers of any given system: the atomic and the structural. How the simultaneity is executed – via interleaving or as an emergent by-product of a finer level's evolution – is largely what defines each of the algorithms presented. We first offer some fundamental definitions and algorithms.

Genetic Algorithms and Hierarchical GAs

Genetic algorithms (GAs) form a technique of artificial intelligence that iteratively converges on a solution by employing techniques borrowed from genetics. Solutions are iteratively refined executing a series of *generate-measure-select* sequences as shown in Figure 1 below. Problem states (chromosomes) are represented as binary strings, and are iteratively improved upon until a nearoptimal solution is attained.

The *measure* step in the algorithm involves the invocation of a *fitness function* to produce a valuation of the merit of that chromosome. The *selection* step involves a ranking mechanism to choose those chromosomes that will serve to produce future chromosomes for the next iteration. The *generate* step involves the creation of future chromosomes using the binary manipulation operators of mutation, selection, and crossover [Holland 1989].

¹One of these systems was presented in a previous paper. Both systems are used here for illustrative purposes of the framework being presented.





A hierarchical genetic algorithm (HGA) converges on a solution at both the atomic and structural levels (see Figure 2). They are particularly effective in domains where both fundamental building blocks and optimal configuration from structure among the building blocks is sought. HGAs use a nested *create-measure-select* algorithm in both the small and the large. It is exactly how the nesting takes place, both algorithmically and within the chromosomal

Figure 2: HGA Internal Structure



syntax, that determines the author's taxonomy described in this paper.

How HGAs Have Been Used

In past work, the author and her students have used HGAs by strategically ordering selected chromosomes and by retaining unselected chromosomes of the building block. For example, in our music generation system, MELEC [Calvo2011], we intentionally included a series of chromosomes to musically reflect the motif's evolution. Thus, part of the overall form of the musical work was the embodiment of the process of evolution. Our HGA formed an overall system (musical piece) that structurally depicted the evolutionary process of the atomic level building block (the musical motif).

MELEC (Meta-Level Evolutionary Composer)

In [Calvo2011], our implementation of the metalevel evolutionary composer (MELEC) system was shown to be capable of autonomously generating melodies through the use of HGAs. The system uses a GA to generate musical motifs and iteratively refines them through evolving generations. It utilizes nested evolutionary computation: one computation generates motifs and another arranges them to form the musical structure. Since each motif is not altered in successive computations, MELEC generates melodies that stimulate a sense of familiarity in listeners by playing the motifs in an order that reflects their evolution. The significance of this work is that it pushed the boundaries of GAs into a realm of performing simultaneous evolution at both the atomic and structural levels while including a "history of evolution" within the solution itself.

Complex Adaptive Emergent Systems (CAESs)

CAESs are made up of components nested in larger components, and often behaviorally defy compositionality by exhibiting emergent properties. By definition, CAESs exhibit the following properties: emergence, co-evolution, suboptimality, variety, connectivity, simple rules, iteration, self-organization, and nested systems [Eindhoven, 2004].

Because of their implicit nested structure, self-Figure 3: Example Complex Adaptive Emergent System



Comprised of heterogeneous, interacting, adaptive agents exhibiting properties of self-organizing emergence and connectivity [Ahmed 2005].

organizing and iterative nature, the author contends that HGAs show great promise to provide a more effective and accurate form of modeling of CAESs. Moreover, by using HGA's to intentionally generate systemic simulations of CAESs, we expect to gain insight as to how CAESs are triggered, internally controlled, and sustained. By applying the nested HGA formalism, we hope to expose and more clearly define a new genre of problems: those that can be purposefully evolved with a *semi-controlled emergent behavior* (that is, through the direction of an HGA).

The HGA Taxonomy

The following algorithms are based on evolution at the atomic and structural levels by alternating the execution of respective cycles of *generatemeasure-select*. In so doing, the solutions generated all exhibit an implicit self-organizing, iterative, and nested structure.

Two Formalisms

We have devised two formalisms of HGAs: composite and nested. In the *composite* formalism, atomic and systemic chromosomes share at least one property or goal. Thus an intentional modification to an atomic chromosome will directly affect the encompassing structural chromosome. In the nested HGA formalism, however, atomic and systemic chromosomes independently attempting evolve to attain seemingly unrelated goals. In either the composite or the nested HGA formalism, the atomic chromosome may be a substring of the structural chromosome.

Composite HGAs

The salient characteristic of composite HGAs is that the atomic and structural levels share at least one goal. Thus, the atomic and systemic chromosomes share at least one property. The valuation (fitness) functions tend to be hierarchical or recursive, and the algorithm may order and retain un-selected chromosomes at the atomic level in construction of a chromosome at the outer, structural level. Evolution of the atomic and structural levels takes places separately. As mentioned earlier, MELEC exemplified this technique in its production of music. Other examples of genres of systems that could exhibit composite properties are those related to computer art using fractals.

Nested HGAs

Nested HGAs simultaneously evolve atomically and systemically. By using separate fitness functions. however, atomic and systemic evolve attempting chromosomes to attain seemingly unrelated goals. There is an implicit nesting of chromosomes where the systemic chromosome is (possibly partially) composed of atomic chromosomes. The amalgamated structural chromosome, however, is interpreted differently using its own higher level fitness function that realizes the overarching system goal.

To date, we have experimented with two different sets of systemic/atomic chromosome configurations. There are, however, numerous more possibilities. Specifically, nesting naturally depicts layers of the structure of the problem being modeled. Thus, the nesting of atomic chromosomes within the systemic one can structurally mimic the real-world system being modeled.

An intuitive way to exemplify the nested HGA approach is to consider individual atomicchromosomes as individual binary strings. The concatenation of the binary strings forms the metachromosome and can be equivalently interpreted as a string of hexadecimal digits each comprised of four bits. Thus, we have simultaneously represented two levels of structure with one binary string: the atomic bit level, the structural hex level. Using the *generate-measure-select* cycle on either level could have evolutionary effects on the other.

HGA Algorithms

The Emergent HGA algorithm is a nested HGA. Shown below in Figure 4, the systemic solution is evolved as a by-product of atomic genetic operations. Even though no explicit operations are applied at the structural level chromosome, that chromosome is transformed 'emergently' by the directed evolution of its constituent atomic chromosomes.

Figure 4: Emergent HGA Algorithm



Simultaneously evolving systemic and atomic structure by participating in an inner (atomic level) iterative cycle of *generate-measure-select*

In the Level Alteration Algorithm shown below in Figure 5, a controlled level of alternation between the atomic and system components is used. Each level has its own set of genetic operations randomly assigned. In this approach, genetic operation at the structural level will preserve atomic chromosomal boundaries. The algorithm is exemplified in our graph theoretic problem below.





Evolving systemic and atomic structure by interleaving between inner (atomic level) and outer (structural level) iterative cycles of *generate-measure-select*

HGAs and Graph Theory

One genre of problems that allow us to study CAESs using HGAs are graph theory problems. The undirected graph is a fundamental, widely used formalism for problem representation [Gross1999]. Moreover, cellular automata, which are based on one graph, have been successfully used to model CAESs [Fryer2004]. Our interest in expanding the consideration of graph theory to HGAs and CAESs is that many graph theory algorithms require both local and global attention.

This 'zooming in' at each vertex and 'zooming out' to consider the whole graph as a structural entity is precisely the interaction of an HGA system as it vacillates between the atomic and structural levels.

Graph Theory and Euler Tours

In this early work, we have implemented a system to generate Eulerian Graphs (i.e., graphs that have Euler tours) [Wei2011]. *Finding an Euler tour* is a problem that challenges the reader to find a trace of every edge of the graph exactly one time and then return to the starting vertex, without lifting one's pencil [Epp2011]. Euler showed that only graphs made up of even-degreed vertices² of at least degree two, have an Euler tour.

In our implementation, each atomic chromosome evolves a vertex. Since we know that each vertex must has even degree of at least two, our atomic fitness function can easily reward these local properties by simply adding the values of the



chromosome as shown in Figure 7.

Figure 7: Atomic Level Chromosome corresponding to vertex A and its neighborhood

03	1	2
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At the structural, global level, an Euler tour mandates that every vertex is accessible from the starting point (called "source"). In particular, the global graph in which the Euler tour exists must be

² An even-degreed vertex is a vertex that emanates an even number of edges. In Figure 6, vertex A has degree 6, and vertices B, C, and D have degree 4.

strongly connected; the graph is inclusively one connected component. As shown in Figure 8, the structural-level chromosome is made up atomic level chromosomes and is (emergently) affected by atomic chromosomal manipulations as well as being explicitly transformed by structural level genetic operations.

Figure 8: Structural Level Chromosome corresponding to graph of Figure 6

0	3	1	2
3	0	1	0
1	1	0	2
2	0	2	0

In our implementation, we used the Level Alternation Algorithm (Figure 5) and successfully evolved many Eulerian graphs. The two phases of alternation were defined by the two main properties discussed above: every vertex has even degree of at least two, and the graph is one connected component (that can be verified with the depth first search checking for accessibility of each vertex.) The structural chromosome represents the full graph and its fitness function rewards maximal accessibility. Moreover, each row of the adjacency matrix is made up of an atomic level chromosome. The atomic level fitness function rewards even degree (easily computed by summing the values of the atomic chromosome).

The program alternates between the *generate-measure-select* phase of the both levels and each evolutionary phase runs for a ³pre-selected amount of time after which the resultant evolved information is passed to the other level for processing.

Conclusions

We presented a taxonomy of hierarchical genetic algorithms and techniques that the author has used in recent work [Calvo2011] [Seitzer 2010] [Wei2010]. For

some problems (such as generation of Eulerian graphs), it is possible to nest atomic chromosomes inside structural chromosomes, and apply the *create-measure-select* iterative GA to one, or the other, or both levels. Using these techniques, we were able to generate interesting solutions that emerged by iterating chromosomes that selforganized through the genetic operations, were interconnected by the underlying representation of the graph, and were intrinsically nested by definition. Thus, these emerging, self-organizing, connected solutions are clearly the precursors of complex-adaptive-emergentsystems.

Future Work

Currently, our most pressing goal is to increase the magnitude of the problem sizes in Eulerian Graph generation and to expand our repertoire of graph theory problems we tackle. We are currently working on the design of a graph coloring HGA using both the Emergent HGA algorithm (as shown in Figure 4) and the Alternating Level algorithm (Figure 5).

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³ In future work, we expect to experiment with phase time selections.

Aalto LAB Mexico, A Knowledge Exchange Experiment in Design Education

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ABSTRACT

The dynamic and interactions of very large systems in which we find ourselves existing and engaging with, can at the very least be difficult to navigate, or worse, dictate disastrous directions. As suggested by Ackoff and others, has at the very least been structured to satisfy only particular levels of large social systems?

Large system scale interaction raises questions regarding interactions between fields of expertise and learning. In particular, what are the relevant systems level impact, and why are these impacts important? These questions led to a key question regarding work discussed in this paper, what can design as a field or way of thinking provide for the multiple or "polydisciplinary" approach?

This paper discusses attempts to identify relevant interactions of a poly-disciplinary approach and impacts through a case study instance, based on research, current literature and fieldwork with communities in Mexico.

Keywords: educational knowledge platforms, design thinking, systems thinking, project based learning.

1. INTRODUCTION

When asked to give an account of his lifelong work on systems thinking on a homage for his 80th birthday, Dr. Russell Ackoff acknowledged the following as one of his greatest revelations:

"Most large social systems are pursuing objectives other than the ones they proclaim, and the ones they pursue are wrong. They try to do the wrong thing righter, and this makes what they do wronger. It is much better to do the right thing wrong than the wrong thing right, because when errors are corrected, it makes doing the wrong thing wronger but the right thing righter." (Ackoff 1999).

Among those social systems that pursue the wrong, Ackoff (1999) named the educational system and the corporations, citing current educational systems that advocate teaching, rather than learning; therefore, teachers learn more than students. On the whole, the system broadly supports "learned" rather than "learning" organizations. While corporations fail to care or focus on those who spent most their time in it (employees), the corporations' main focus seems increasingly occupied by the living standards for those at the top. These sentiments are echoed as he discusses how the educational systems have been designed to satisfy that industrial society (Ackoff 2010).

Ackoff's appraisal of the educational system is in step with Dr. Martha Nussbaum's criticism of universities globally dropping Humanities and Liberal Arts. Her main argument in *Not For Profit: Why Democracy Needs the Humanities* (Nussbaum 2010) is that if we aim to live in a democratic world, schools need the competence for producing citizens capable of being democratic; because the inhabitants of the world are closely interrelated, so regardless of distances and traditions, "inter-dependence" is critical regardless of the individuals' awareness of others. (ibid.). No one is exempt; "education, then, should equip us all to function effectively in such discussions, seeing ourselves as 'citizens of the world'" (ibid.)

This paper discusses Nussbaum's and Ackoff's arguments of educational misdirection, reflecting upon the Design debate, which considers Sustainability as the core challenge of our times (Papanek 1985, Manzini 2007, Fuad-Like 2009, Fry 2010). Work discussed in this paper introduces Design as a collective platform to support interaction between disciplines (Findeli 2001, Waks 2001, Nousala, et al. 2012) including, the necessity of creating fundamental links with Humanities.

To highlight the Humanities argument, this paper will refer to case study instants based on research and fieldwork from an ongoing project called Aalto LAB Mexico. There are various layers of interaction within the Aalto LAB Mexico project made up of interactions between several groups of participants. Due to richly layered interactions within the Aalto LAB eco-system, this paper limits itself to our observations and discussions of the student's involvement and experiences.

2. DESIGN IS THE PARADIGM OF SYNTHETIC THINKING

Design is holistic, a synthetic answer to interdisciplinary and complex problems; "Design is the paradigm of synthetic thinking" (Ackoff 2010). Within the world of design, it has been widely accepted to address Sustainability as the greatest challenge of our times (Papanek, Manzini, Fuad-Luke, Thackara, Van der Ryn); and without a doubt, dealing with Sustainability requires complex adaptive systems thinking (Nousala et al.2012).

Design deals with change made by choice (where change is planned). Now that it has broaden its interests from products to services, begins by identifying that something in the starting state of a system is not right, or could be improved. The next step is *envisioning what that system ought to be*. Finally, the process defines a causal relationship from A to B (Findeli 2001).

Sustainability can be approached as a design challenge. Fry calls the first state, the *structurally unsustainable* (Fry 2010); like Ackoff, he recognizes that the current human systems are "wrong". The desired state for the world is Sustainability (whatever it exactly means).

However, if it is the *metachallenge* (Fuad-Luke 2009) of our times, it cannot be a task exclusive to the field of Design. What *the world ought to be*, must be defined and constructed by the Humankind. Sustainability requires people from all fields to develop design skills, or at the very least recognize what these skills are. Schön (2001) was also sympathetic to the notion that all disciplines are design-like; they include conceptualizing and implementation phases (Schön in Waks 2001), Design becomes the common platform through which different disciplines interact (Nousala et al. 2012).

Project based learning might be an instrument through which design education becomes central to all fields. If the project is one of the real life; the students' engagement will be greater, like their knowledge construction (Findeli 2001, Jones 1997, Nousala 2012).

3. DESIGNERS TOO, ARE HUMAN BEINGS

In *Design for Services* (Meroni & Sangiorgi 2011), Ezio Manzini raises the question whether designers should limit their participation to assisting the visualization of scenarios or if they should contribute to envisioning. His opinion is that designers should also be provocative proponents in order to nudge the conversations beyond what non-designers bring forward. Nussbaum, on her part, argues that liberal arts should be inherent to every individual's education (Nussbaum 2010).

The task of facilitating the conversation that would define *what the world ought to be* is a role that carries a deep responsibility within; and if that is the role of

designers, then designers must be able to reflect and make morally informed decisions. They must be aware of the debates that Humanity has kept to itself from the beginning, for before being design professionals; *designers too, are human beings*.

If Design is to contribute to Sustainability, its overall purpose and education must be redefined; then Nussbaum's words become extremely relevant: "... If we do not insist on the crucial importance of the humanities and the arts, they will drop away, because they do not make money. They only do what is much more precious than that, make a world that is worth living in, people who are able to see other human beings as full people, with thoughts and feelings of their own that deserve respect and empathy, and nations that are able to overcome fear and suspicion in favor of sympathetic and reasoned debate." (Nussbaum 2010)

4. PROJECT BASED LEARNING: CASE STUDY INSTANTS FROM AALTO LAB MEXICO

This project is an ongoing educational exercise that aims (among other layers that will not be discussed within these pages) to nudge the students' interest towards matters traditionally exclusive to the humanities field through design thinking. It consists on a remote research period and a fieldtrip, and was designed to actively engage the students in producing knowledge and raising their social awareness.

4.1 AALTO LAB – SELECTING THE REGION

Aalto LAB Shanghai (ALS), initially took place in Shanghai in 2010. Aalto LAB Mexico (ALM) followed in 2012, with the intent to iterate ALS. The region selection was important part of the process with regards to interactions and the development of the project.

A "region", as expressed by Gimenez (1994) was defined as the interaction between a physical environment and the people that live within. These interests were at the project's core interest. Aalto LAB's ambiguous task "to make the world a better place", was influenced and shaped through selecting a region. When the students were briefed about the region, they are actually had been given a project based learning setup.

The region in Mexico was selected in accordance with four criteria, following the previous ASL model, (1) the community had to be involved in some sustainability project and (2) the hosting university, preferably its design program, should be developing a community project there (as a partnership with a university was identified as one of the community's greatest assets). Specifically in the case of Mexico, (3) the community had to have the classification of marginal (those whose basic rights are neglected (Rodríguez 2010)); finally, (4) it was necessary to find a location safe from the drug war conflict. The region chosen, was a small commune (where the State University of Mexico, UNAM) had developed a workshop previously), located in the Yucatan Peninsula, next to the largest protected biosphere in the country, and in one of its poorest states, where the inhabitants are predominantly descendants of Mayan immigrants.

4.2 AALTO LAB – SELECTING AND DEVELOPING THE FIELD TEAM

The selection and development of the field team involved four groups of participants that formed a "layer" approach to project activities. The student team (LABBERS) were selected through an open application process, to form a team consisting of 13 students from Finland and Mexico. The student's were from diverse fields, ranging from Art and Design, Humanities, Business, and Engineering.

This process included the use of industry "facilitators" with design backgrounds from the IDEO company, who had also facilitated in the previous ALS project.

The "experts" were a group of people from various fields (Design, Social Sciences and Engineering) and provided consultation and mentoring throughout the project.

The final group was the "documentation" team was formed by a group of design researchers including a documentary film maker and a photographer.

4.3 PREPARATION PERIOD

In ALM, the LABBERS had two months to get ready for a two-week fieldtrip. They were encouraged to propose research topics to self direct their learning, through shared discussion and exchange. Prior to visiting the region, the aim was to ensure and encourage preparation, but without pre-conceived or planned outcomes, promoting a more bottom up, emergent process. Although no formal syllabus was introduced, some experts in topics crucial to ALS were invited to lecture to encourage more emergent type process, for example, discussion around "Design Probes" (Mattelmäki 2006), was used to introduce design concepts to the process.

The LABBERS in Mexico researched "development" and "the indigenous people". Soon, they were discussing one of the greatest current controversies in Mexican Ethnology; how to define 'indigenous' (Vázquez, et al. 2011) now that both elements: race and language are outdated. The LABBERS were unable to define the *otherness*; in the presentation that was supposed to define *indigenous*, concluded it with a slide that read "I don't know!" The fieldtrip was perceived as indispensable for clarifying their questionings.

4.4 SEMINAR, ENCOURAGING THE LABBERS

The team met in Mexico City before the fieldtrip, for a seminar named "Designing for Social Sustainability, a Poly-disciplinary Approach" in Tec CCM; where Sustainability was approached from various fields

(Complex Adaptive Systems, Biology, Architecture, Engineering, Social Policy, Energy, and Design). These two days helped the LABBERS integrate and gave room for a crucial activity to take place, a reminded that the goal of their fieldtrip was to put into action their ideas through project based learning.

4.5 FIELDTRIP: THE PRIME STAGE

The team worked within and together with the community, experiencing a different way of living, conducted interviews, and shared their findings with each other. The LABBERS reflected on topics from the previous stages, commenting that "If everyone thought a little bit like Oscar Hagerman, the world would become a better place" (Hagerman is an Architect who has been working for decades with indigenous groups all over Mexico, and one of the speakers of the seminar).

The next stage was analyzing and classifying the LABBER's learning into "opportunity areas". There were not many things that the inhabitants wanted to change, and some of the issues were too big for the LABBERS to tackle (for example, the lack of health care services). Whilst LABBERS expressed their admiration to the artisans, they also felt privileged to have had the exchange. Both LABBERS and community believed they had learned a lot while being closely engaged. LABBERS were committed to create realistic proposals that would be valuable for the region. They worked on ideas that were feasible and would empower the community from within and that could potentially contribute to bigger issues, at later stages.

5. DISCUSSION

Aalto LAB was experiment in design education that intended to provoke interest to extend and construct knowledge in humanities through and exchange with design thinking. The model is supported by the statements that Humanities are fundamental in constructing a democratic society (Nussbaum 2010), that design as an approach, like education encourages real learning (Ackoff 2010, Waks 2001, Findeli 2001), and that experience is a crucial factor for a learning community to construct knowledge (Nousala 2012, Jones, et al. 1997).

The results of design as the focus of an approach have been encouraging, providing a working common platform for multiple disciplines to interact. All LABBERS recognized the relevance of their participation in bringing forward their field's perspective and enjoyed applying the methods. Marc Steen wonders how to balance the users' concerns with the project team members' ambitions in these type of projects (Steen 2011). In ALM, the preparation period seemed to positively affect the LABBER's attitude in the field: all of them arrived in the community willing to learn and listen; they wanted to contribute in improving the community, and made an effort to remain neutral rather than imposing. The fact that it was self-directed created some confusion, but also motivated them to be more active with the learning process.

THE LONGITUDINAL ELEMENT

A critical factor was the element of time, that allowed the overlapping of exchanges, not just for participants but those engaging with the project through external connections. This was evident when the ALM developed various stages that were not necessarily linar, but overlapping exchanges of disciplinary experiences and approaches that produced emergent concepts and responses to current, on-going and future events. These responses were themselves the result several cycles of trial and error as shown in figure 1.



6 months preparation and fieldtrip 1

6 months reflection

6 months preparation and fieldtrip 2

Figure 1: **TIME**, Accuracy of understanding, **OODA*** **CYCLE**, Problem solution,***OODA**: Observe, Orient, Decide, Act. (Nousala and Garduno 2013: Nousala and Hall 2008).

6. FOR FUTURE CONSIDERATION

The experts that visited the field gave an account of their observations, proving that extremely relevant matters are unknown to the villagers, therefore cannot be informed through interviews. However, this project is aware of those matters (water, electricity, and governance), which cannot be ignored when envisioning the region's future. Thus, the project could generate subprojects to be developed throughout a longer period of time. We believe that adding an implementation phase would greatly strengthen the learning experience; and we reckon that it would require much more funding.

Having facilitators separated from a research unit seems to allow the workshop's fluent development and its neutral observation. Nevertheless, ALM's layered structure could be greatly improved in later editions.

7. CONCLUSION

The design approach is potentially the greatest platform for poly-disciplinary interaction, design thinking should become part of all disciplines' curriculum; on the other hand, involving Design in Humanities seem key to identifying *the right thing to do*.

Aalto LAB is a collective platform for poly-disciplinary interaction that contributes to educating the citizens of the world that we desperately need. On one hand, it helps students to develop the skills to envision an alternative reality. On the other hand, the students get to know people from a far off place who might somehow be affected by their daily actions; and if the preparation phase of the LAB has been successful, they earn the ability to recognize them as fellow citizens.

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A PROPOSED MODEL FOR TRACKING THE UNIVERSITY INTERDISCIPLINARY PROJECTS

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ABSTRACT

Interdisciplinary is the concrete interaction between two or more knowledge fields, leading to a transformation of any of the involved disciplines. It is proposed that the way to measure if an interdisciplinary project is successful is to show the transformation of the key concept(s). The model proposes to establish an initial conceptual basis for each discipline, and a crossing matrix of the same or similar concepts from all disciplines used in a research project. At the conclusion of the project, the reformulated concepts are verified into the matrix.

1. INTRODUCTION

At the universities, interdisciplinarity is proposed as a way through innovation (Cabrera, 2006). It's not easy to demonstrated if an interdisciplinary research project has been succesful, because it's hard to show the knowledge fields transformation.

2. PROPOSED MODEL

Research projects for innovation are involved in a middle and long term processes. These processes begin with an interaction of knowledge fields (Piaget, 1973) reveling three moments:

i) <u>First moment</u>: to promote and to manage <u>Multidisciplinarity</u>, that means the colaboration between disciplines involved in the efforts to resolve an specific problem. In this moment it is necessary to specify clearly the research lines in every discipline involved. For each research line there must be a responsible person designed.

ii) <u>Second moment</u>: The holistic vision of the project and the management must be in charged of the University Research Department, in order to promote and to manage <u>Interdisciplinarity</u> to solve *complex problems* (Morin, 1996) or to create *revolutionary science* (Kuhn, 1962) beyond *the Scientific Method* (Asimov, 2007).

iii) <u>Third moment</u>: walking through <u>Transdisciplinarity</u>: remove Faculties as promoters of

research (Martí Marco, 2012); and create dynamically research units ad-hoc for research projects.

2.1. For the first moment, <u>Multidisciplinarity</u>, the research project profile must include:

a. A table that clearly identifies the different lines of research to be addressed and which skilled professionals will be involved in the investigation of each line.

Table #1:Disciplines, Areas and Lines of Research

	DISCIPLINE 1	
Knowledge Area	Research Line	Expert
	DISCIPLINE 2	
Knowledge Area	Research Line	Expert
	DISCIPLINE 3	

b. In the schedule, pinpoint the stages in which the expert professionals get involved by specialty.

2.2. For <u>Interdisciplinarity</u>, in the research project profile add:

- a) A <u>conceptual basis</u>, identifying the concepts on which the research will be conducted.
- b) If a concept has different meanings in each discipline or research area, it is neccesary to register all these meanings following the next steps:
 - a. Set down a *Concept Definition* for each discipline:

Table #2: Concept Definition



b. Every Concept Definition must be allocated in a Table called: <u>Interdisciplinary Conceptual Basis</u>

 Table #3: Interdisciplinary Conceptual Basis

INTERDISCIPLINARY CONCEPTIAL BASIS						
CONCEPT	DISCIPLINE	KNOWLEDGE	CONCEPT			
		AREA	DEFINITION			

- c. Analyze each Concept Definition in order to determine areas of influence and expertise of each concept. This analysis shows the differences of the same concept in different disciplines and areas of knowledge.
- d. If applicable, try to make a graph showing the relationship of the different definitions of the same concept.
- c) Perform a matrix or *matrices crossing the lines of research* in different disciplines. To do this, It should be taken into account that:
 - a. There may be several types of crossings, among research lines of the same subject, or among different lines of research disciplines.
 - b. Organize level interaction of disciplines in binary form (KA: Knowledge Area; RL: Research Line):

K.Á. 1.1 K.Á. 1.2 R.L. I.1.3 I.2.1 I.2.2 I.2.3 Y R.L. R.L. R.L. R.L. R.L. I.2.3 I.2.3 Y R.L. I.1.3 I.1.3 I.2.1 I.2.3 I.2.3	DISCIPLINE 1			
R.L. R.L. <th< th=""><th></th></th<>				
RL. 2.1.1. RL. 2.1.2. RL. 2.1.3	L. .2.3.			
RL. 2.1.2. RL. 2.1.3				
R.L. 2.1.3				
Display R.L. 22.2.1 2.2.1				
RL. 2.2.2.				
R.L. 2.2.3.				

Table #4: Crossing Matrix between Research Lines

Create as many matrices as combinations of interacting disciplines there should be done: one matrix for 2 disciplines, three matrices for 3 disciplines, six matrices for 4 disciplines. The number of matrices is a combination of n things taken 2 by 2 regardless of the order. The formula to calculate the number of tables / matrices is:

$$\frac{n!}{(n-2)!} * \frac{1}{2!}$$

- d) In the crossing points write down the concepts that may have changed during the development of the research project. Consider all the concepts of the Conceptual Basis.
- e) Incorporate a Concept Map (network concept) that summarizes the relationship among all the concepts.
- 2.3. The Management or Research Department appoints an Ad-hoc Committee (due to Budget and the dynamics of the projects) consisting of experts in the knowledge areas involved and related that will discuss: the conceptual basis, the crossing matrices, and the concept map in order to help in their accuracy, and as appropriate, involve other actors and concepts related to the project.
- 2.4. In the project progress milestones, it is necessary to review possible concept changes using the Conceptual Basis and the Crossing Matrices Chart.
- 2.5. Interdisciplinary is achieved if:
- 2.5.1. One or more of the concepts are transformed, since they were conceived differently in each discipline at the beginning of the research,
- 2.5.2. A new common concept for several disciplines emerge.

3. CONCLUSIONS

The proposed model shows the transformation of the fields that have interacted within the investigation.

Monitoring the changes of the involved concepts in a research allow to track the transformation of the disciplines.

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A Phenomenological Approach to Value

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ABSTRACT:

A natural phenomenon predicted locally in the brain is seen to fit globally also. The morphology implied by the model has direct consequences for the kind of logic operative in the nervous system. Because of the non-Aristotelian philosophical basis of the theory, the closest approach of relevance to Artificial Intelligence appears to be Professor John MacCarthy's non-monotonic logic.

Keywords: Elementary Catastrophe Theory, Synapses, Poincare – Dulac, Morphic Resonance, Arrow Impossibility Theorem.

1. INTRODUCTION

Drawing on an old philosophical idea equating value to energy (Jean Ville, 1946), we identify the physiological potential as predicted (in the region of the Pons) at the level of the junction between the brain and the spinal cord with the intensity of the output to an external stimulation in a responsestimuli model. Since any representation of the world entails as a central problem the subject of scale, we show how one black box model of the brain allows us an original resolution of the old duality of free will/determinism thanks to the introduction from the outset of the observer as participant in the measurement process.

We focus on a property known as the Impossibility of Aggregation, showing how our approach permits a constructivist interpretation opening avenues for resolution along the lines of finding different rules of addition within the framework of Cauchy equations. Finally, we give our reasons why such a framework could provide added insights, due to its algebraic character, to the intuitive notion of circumscription in Artificial Intelligence.

2. THE MEASUREMENT PROCESS

The basic question we pose is: 'How does the individual process two different inputs in a row, i.e., what, if any, is the scaling function taking the same value either when its argument is z or when we add the respective values of x and y such that z = x + v?

v(z) = v(x + y) = v(x) + v(y)

A special case of Cauchy Equation:

v(xoy) = v(x) + v(y)

the fundamental equation that mathematicians have tried to solve in different contexts, constituting the basic functional equation for a theory of measurement. This formulation put the mental process into a materialistic frame known as the Grassmanian. The important point is that the addition rule on the argument side could be different from the one on the functional space. If we look for a physical process supporting such a algebraic view, we notice that, for about 50 years now, there exists a physiological theory axiomatizing a potential function as mentioned in the Introduction and processed throughout the brain by a network of about 10^{14} synapses predicting as the only stable functional a ratio scale represented by a fifth degree potential:

$$v = \frac{1}{5}x^5 + ax^3 + bx^2 + cx$$

corresponding to dimension 3 of the control space (basic rods or cones for visual perception) and dimension 1 (x) of the state space (input stimulus) in the terminology of Elementary Catastroph Theory the conditions for structural stability, together with homogeneity, give the functional:

$$v = \frac{1}{5} x^5 - \frac{2}{3} x_0^2 x^3 + x_0^4 x$$

3. A FORMALIST APPROACH

Taking the derivative of our potential gives us our expression of a force field as follows:

$$v' = x^4 - 2x_0^2 x^2 + x_0^4 = (x^2 - x_0^2)^2$$

This algebraic picture is seen to be compatible with a Machian view of the force as the result of inertia there inducing inertia here; or in other words, depicting value as the expression of the subject's attractiveness in the presence of the object of his(her) attention.

The simplest way to make the result intuitively appealing without any recourse to E.C.T. axiomatizing is to consider the derivative of value as a mapping:

 $\nu': R_e \to R_e^+$ Which has to reach its minimum, 0, being the absolute one in absence of any restrictive assumptions, at some point X_0 . but at this point by its non-decreasing feature, its derivative, i.e, v" has also to cancel. Therefore X_0 is double root of V. by the further assumption of symmetry toward the origin, by the principle of insufficient reason to the contrary, its symmetric $-x_0$ has the same properties: therefore

 $v' = (x - x_0)^2 (x + x_0)^2 = (x^2 - x_0^2)^2$

$$v = \frac{1}{5} x^5 - \frac{2}{3} x_0^2 x^3 + x_0^4 x$$

Since

$$v(x) + v(-x) = 0 \Longrightarrow v(0) = 0$$

The black box of the brain is subject to determinism due to its interaction with its physical milieu, but the point of reference to which the input is compared, aggregate of the psychic representing an phenomenon and parameterizing completely the control space of dimension 3, is an unfathomable island of free will or volition.

In computer terminology, the likely picture is one of software built in the hardware. A relevant theory of the brain as a holographic process has been advanced by K.Pribram and D.Bohm, compatible with the singularity concept, an essential ingredient to E.C.T. The second essential ingredient being the concept of analytical continuation. They are essential in the sense of allowing the representation to go from the local to the global, hence to be complete.

It is not the appropriate place here to elaborate on the ambitions that the author (R.Thom) nourished toward his theory (E.C.T.). Nevertheless, the view I m unfolding constitutes, I think, the closest interpretation of its author and hence the best chance it has to fulfill its promises. To that effect, I will only mention the crucial new concept of self-duality valid

with our functional because the control space (regular physical one) has dimension 3, compatible with the tunneling effect in quantum theory and the collapse of the wave function in the Von Neumann measurement process. Also compatible with it is the hidden parameter theory being revived by D. Bohm.

Before leaving the domain of physics, we should mention the representation of free energy in ferromagnetism around the critical point $x_0; A +$ $Bx_0^2 + Cx_0^4 + \cdots$ and in thermodynamical scaling where the exponent 5 of the state variable around the critical point has been identified, corresponding to dimension 3 of the parameter space. This again is an added feature of E.C.T. connecting its ultimate purpose of geometrizing thermodynamics with the hypothesis well-known scaling in critical phenomenon. Finally, a succinct picture of the brain, functioning at normal temperature like а superconductor at 0°K (Kelvin), provides an additional impetus to the overall conjecture that such a theory may have closed the gap between the physical and the mathematical continua.

For our purpose, it is pertinent to notice that starting from a fifth degree polynomial the observation process ends up with a shape symmetric toward the origin and affording a simple interpretation under the necessary assumption of a nondecreasing function. Last but not least the symmetrical shape put our formula within the scope of the theorem (Poincare -Dulac) on normal forms deployment around the critical point in case of resonance, completing the picture of "Morphic Resonance" à la R Sheldrake and the linkage of thermodynamics with the quantum level. Thus the importance of verifying the empirical grounding of our quintic.

Although this polynomial checks the most well known criteria for value functions, like the S.Ross' one, verified at Oslo in 1982, I present here only the cardinal impossibility result corresponding to Arrow famous Theorem. The aim is to show that there is a way out of the impossibility by imagining a rule for aggregation other than the usual arithmetic addition. Also, it's easy to prove that we have here a situation closest to a possibility result, by showing that we can disaggregate the representative function uniquely into 3 individual ones, one real and 2 complex conjugates.

4. AN IMPOSSIBILITY RESULT Formulation:

Let the set i = 1, 2, ..., n represent the different individuals parameterizing their utility functions as follows:

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$$v_i = \frac{1}{5} x^5 - \frac{2}{3} a_i x^3 + a_i^2 x, \qquad a_i \ge 0$$

We are looking for a_o whose utility is a weighted sum of the n individuals:

$$\frac{1}{5}x^3 - \frac{2}{3}a_0x^3 + a_0^2x$$
$$= \sum_i \alpha_i \left(\frac{1}{5}x^3 - \frac{2}{3}a_ix^3 + a_i^2x\right)$$

With

$$\sum_i \alpha_i = 1, \qquad \alpha_i \ge 0$$

Identifying the coefficients of the powers of x, left and right:

$$a_0 = \sum_i \alpha_i a_i$$
 and $a_0^2 = \sum_i \alpha_i a_i^2$

Therefore, a condition of compatibility:

$$(\sum_{i} \alpha_{i} a_{i})^{2} - \sum_{i} \alpha_{i} a_{i}^{2} = 0$$

Developing and simplifying:
$$\sum_{i} \alpha_{i} (\alpha_{i} - 1) a_{i}^{2} + 2 \sum_{i < j} \alpha_{i} \alpha_{j} a_{i} a_{j} = 0$$

Which is recognized to be:

$$\sum_{i< j}^n \alpha_i \alpha_j \ (a_i - a_j)^2 = 0$$

Assuming that all individuals have the same weight $(\alpha_i = \frac{1}{n}, i = 1, ..., n)$:

$$na_0 = \sum_i a_i$$
 and $na_0^2 = \sum_i a_i^2$

(1) Compatibility requires:
$$\sum_{i< j}^{n} (a_i - a_j)^2 = 0$$

 $(n-1) a_n^2 - 2a_n \left(\sum_{i=1}^{n-1} a_i\right) + (n-1) \sum_{i=1}^{n-1} a_i^2$
 $-2 \sum_{i< j}^{n-1} a_i a_j = 0$

The discriminant

$$D'_{n} = \left(\sum_{i}^{n-1} a_{i}\right)^{2} - (n-1)^{2} \left(\sum_{i=1}^{n-1} a_{i}^{2}\right) + 2(n-1)\left(\sum_{i$$

Proposition:

For n individuals whose cardinal indices are all real, we cannot have a real representative of their aggregated preferences over the whole range of variation of the variable x, unless all n individuals are identical.

Proposition:

Even when there is such a representative (for some indices ε C), the set of such indices, including the representative, is defined up to scalar addition and scalar multiplication (affine transformation).

Proof:

Set
$$a'_i = \lambda a_i + \mu$$
 $\lambda, \mu \in C$.

With $na_0 = \sum a_1$

$$na_0^2 = \sum a_i^2 \ then \ a'_0 = \lambda \left(\frac{\sum a_i}{n}\right) + \mu$$
$$= \lambda a_0 + \mu$$

Now
$${a'}_0^2 = \frac{\sum a'_i^2}{n} = \lambda^2 \frac{\sum a_i^2}{n} + 2\lambda\mu \frac{\sum a_i}{n} + n \frac{\mu^2}{n}$$

= $\lambda^2 a_0^2 + 2\lambda\mu a_0 + \mu^2 = (\lambda a_0 + \mu)^2 = (a'_0)^2$

The expansion of (1) shows that the root a_n will be the average of the previous a_i 's as soon as $D'_n = 0$. Inorder for (1) to be verified, it is readily seen that one or more of the squares under the summations should be negative.

But this is so only if the difference under such square is a pure imaginary number. Because of the symmetric permutation of the indices, an argument could be made that each such couple (i,j) should correspond to a complex conjugate pair. Since the a_i 's are defined up to affine transformation, we need consider only the pure imaginary part.

Let us particularize for n = 3 or pose what we call the Inverse Problem. How to decompose a would-be representative Ω in three "constituents?"

(1) Compatibility gives:
$$a_3^2 - a_3 (a_1 + a_2) + a_1^2 + a_2^2 - a_1 a_2 = 0$$

(2) $\Delta = (a_1 + a_2)^2 - 4(a_1^2 + a_2^2 - a_1 a_2) = -3(a_1 - a_2)^2$.

In order to have a_3 solution εR , Δ must be ≥ 0 , i.e., $a_1 - a_2 = 2j\beta$,

Hence Re $a_1 = \text{Re } a_2 = 0$ where $j = \sqrt{-1} . \beta \epsilon R$. Now, since a_3 and $\sum a_i \epsilon R$, we must have:

 $Ia_2 = -Ia_1 = \beta$ hence a_1 and a_2 are complex conjugate,

Then $\Delta = -3(2j\beta)^2 = 12\beta^2 > 0$ We will retain the only positive root: $a_3 = +\beta\sqrt{3}$.

Hence the average will be: $\frac{\sum a_i}{3} = \Omega = \frac{\beta\sqrt{3}}{3} = \frac{\beta}{\sqrt{3}}$ For n = 4, we have a binomial in a₄:

$$3a_4^2 - 2a_4 (a_1 + a_2 + a_3) + 3(a_1^2 + a_2^2 + a_3^2) - 2\sum_{i} a_i a_j = 0$$

 $\Delta' = -8(1') = 0 \implies a_4 = \frac{\sum_1^a a_i}{3} = \Omega$ as expected

If we were to give a_3 a value between 0 and $\beta\sqrt{3}$, then (l') will be negative and Δ' positive, implying two different real roots for a_4 . Therefore, a decomposition over n = 4 implies an extra degree of freedom for the choice of a_3 and hence is not unique.

We see then that given $\Omega \epsilon R$, we can decompose is uniquely in exactly three constituents:

$$+j\Omega\sqrt{3} = a_1$$

$$-j\Omega\sqrt{3} = a_2$$

$$3\Omega = a_3$$

Because

(1) our impossibility result has the clear expression of a Variance equal to zero

(2) The assumptions leading to our functional are in a sense the weakest we could think of, in line with all the underlying efforts to characterize cardinally Arrow's Impossibility in the ordinal field.

(3) The general form of the possibility theorem with the arithmetic additions gives a shape of:

$$R x^{a+b} + K' x_0^a x^b$$
(T. Schwarz)

We could see now that, starting from minimal assumptions, our approach permits a new interpretation allowing interpersonal comparison of values giving by the same token a superfilter as a result. People familiar with the field of utility would recognize the importance of our result to the classical paradoxes of St. Petersburg and M. Allais

CONCLUSION:

Starting from the idea that we still have a lot to learn from our own brain to gain insights relevant to Artificial Intelligence, we have interpreted a body of ideas (E.C.T.) in the spirit of its author, showing the relevance of the principal features of a functional predicted by the model to our area of interest.

The example of the impossibility of Aggregation was meant to show the kind of insights which could be gained from a methodology based on Heracletian philosophy, having innovative impacts ontologically and emergent properties epistemologically.

Because the most salient points of E.C.T. stress that there is no need to the (1) Law of excluded middle, (2) Law of contradiction, we therefore notice its link with the concept of "circumscription" of J. MacCarthy's philosophical approach.

Starting from the idea that we still have a lot to learn from our own brain to gain insights relevant to Artificial Intelligence, we have interpreted a body of ideas (E.C.T.) in the spirit of its author, showing the relevance of the principal features of a functional predicted by the model to our area of interest.

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The identification of negative Schwarz' Derivative with Systematic Risk Aversion.

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ABSTRACT :

Complementing the accompanying paper on the quintic we generalize the feature of negative Schwarz' Derivative to all utility functions coming from the framework of the Pratt's approach, producing a new premium, and confirming the intuition of M. Allais for the Polynomial shape of utility. The result is shown to be fully compatible with comparative statics and led us to find a new algorithm looking for real roots of polynomials of any degree, due to the overwhelming role played by Taylor series' expansion in applied mathematics.

Keywords: Shwartz Derivative, Systematic Risk Aversion, Comparative Statics, Polynomial adequacy.

1. INTRODUCTION

The Pratt's approach (1964) has been a seminal work on which various theoretical and empirical concepts for insurance and finance have been based. However, it reached very soon its limits for generalization, in spite of the consensus as to the importance of its methodology.

We show in the following pages that the reasons for the deadlock could rigorously be removed by simply expanding the Taylor approximation two more levels. This will result in identifying the negative sign of a third order differential invariant, the Schwarz' derivative, as a practical quantification of the concept of systematic risk. The resulting solution set for the utility functions retained actually enjoys a stronger characteristic involving the derivative of a second order differential invariant, namely $(\frac{U''}{U'})' < 0$.

This fully confirms the specific intuition of Pr Arrow as mentioned in the Pratt's paper, concerning an alternative definition for the absolute risk aversion measure, together with its decreasing behavior. The same characteristic insures not only the convergence of the relative risk measure but also its increasing asymptotic behavior for a distinguished class of polynomials. The premium emanating from this higher level, combined with the reference points, as defined by the critical points of the utility functions, gives a descriptive account of the gambler's behavior independent from probability considerations.

The evidence for the existence of a solution subset monotonically non-decreasing comes from the proof of the Singer's conjecture (1978). It embeds all the polynomial functionals coming from the so -called Elementary Catastrophe Theory under the same roof, namely the negative Schwarz' derivative. This explains and generalizes the main characteristics of an initial solution, the symmetric quintic with its linguistic meaning (Non satiation axiom). This transfer of technology from the domain of hard sciences was suggestive to us because of the old idea equating value to energy, together with the existence of the stimuli response procedure, as traditional in this field of inquiry as Ramsey's approach.

The emerging picture points toward the need for the generalization of the conventional view of preferences representation over a scale defined by two points. Indeed, the latter is seen as a special case of the Mobius transformation toward which the Schwarz' derivative is invariant. Its importance lies in the infrastructure building the foundations of discontinuous groups for linear substitutions in the theory of Fuchsian functions. This richer structure seems to be a necessity, not only on theoretical grounds, but more so for a realistic appraisal of the applications in the physical world, involving people and economic goods with more than one attribute.

2. PRATT'S FRAMEWORK

We start with the general formulation of the risk premium as pioneered in Pratt's paper:

By reducing our consideration to an actuarially neutral case $E(\tilde{z}) = 0$, and expanding U around x, in order to assess π (x,z) as the variance σ_z^2 goes to zero in a first approximation:

$$U[x + E(\tilde{z}) - \pi(x, z)] = E[U(x + \tilde{z})]$$

$$U(x - \pi) = u(x) - \pi u'(x) + \frac{\pi^2}{2} u''(x) + \dots$$

$$E[U(x + \tilde{z})] = E[u(x) + \tilde{z} u'(x) + \frac{\tilde{z}^2}{2} u''(x) + \dots] = U(x) + \sigma_z^2 \frac{u''(x)}{2} + \dots$$

$$\operatorname{Or} \frac{\pi^2}{2} u''(x) - \pi u'(x) - \frac{\sigma^2}{2} u''(x) = 0$$

Considered as a second degree equation in π , we get the solutions:

$$\pi_{1,2} = \frac{(u' \pm \sqrt{\Delta})}{u''} \text{ with } \Delta = u'^2 + \sigma^2 u''^2$$

With $\sigma^2 \Rightarrow 0$ the first root goes to zero:

$$\pi_1 = \left(1 - \sqrt{1 + \sigma^2 \frac{u''^2}{u'^2}}\right) \cdot \frac{u'}{u''} = -\sigma^2 \frac{u''}{2u'}$$

The second root is the relevant one :

 $\pi_2 = \frac{2u'}{u''} + \frac{\sigma^2 u''}{2u'}$

Pushing the approximation to order three:

$$\frac{\tilde{z}^{3}}{3!} u'''(x) + \dots] = U(x) + \sigma^{2} \frac{u''}{2}(x) + \mu^{3} \frac{u'''}{3!}(x)$$

Equating we get: $\frac{\pi^3}{3!} u''' - \frac{\pi^2}{2!} u'' + \pi u' + \frac{\sigma^2}{2!} u'' - \mu^3 \frac{u'''}{3!} = 0 \text{ with}$ $\sigma^2, \mu^3 \Rightarrow 0, \pi \ factors \ out:$ $(*) \pi^{2} - \pi 3 \frac{u''}{u'''} + 6 \frac{u'}{u'''} = 0$ $\Delta = \frac{9u'^{2}}{u'''^{2}} - 24 \frac{u'}{u'''} = 9 \frac{u''^{2}}{u'''^{2}} (1 - 8 \frac{u'u'''}{3u''^{2}})$

In order to have a premium =/= 0 we must have $\Delta > 0$:

With roots:

$$\pi_{1,2} = \frac{3u''}{2u'''} \left(1 \pm \sqrt{1 - \frac{8u'u'''}{3u''^2}} \right),$$

or assuming $u'u''' \ll u''^2$
 $\pi_1 = \frac{3u''}{2u'''} (1 - 1 + \frac{4u'u'''}{3u''^2}) = 2\frac{u'}{u''}$

$$\pi_2 = \frac{3u''}{2u'''} \left(1 + 1 - 4 \frac{u'u'''}{3u''^2} = \frac{3u''}{u'''} - 2 \frac{u'}{u''}\right)$$

Therefore this higher order brings a new premium. We will show consequently that the negativity of Schwarz' derivative of the utility function is the main characteristic of this premium. Also it is the relevant one at this level since we are looking for the root with the maximum modulus. We prove this assertion immediately:

Proposition: (Saade, 1984) Whatever the signs of U',U',U"' and the premiums, we always have the following:

(I)
$$|\pi_1| < |\pi_2|$$

(II) $Su_{\pi_2} < 0$

Where | | is absolute value and SU_{π_2} the Schwarz' derivative associated with the root π_2

From equation (*) and $SU = (\frac{U''}{II}) - (\frac{3}{2})(\frac{U''}{II})^2$ Proof: Let U'>0. a. $U'' < 0 < U''': \pi_1 < 0; \pi_2 < 0$ Since $\Delta > 0$ we have: $(3\frac{\tilde{U}'}{U''}) < 8(\frac{U'}{U''}) < 0$ $4(\frac{U'}{U'}) < 2(\frac{U'}{U'})$ So $3\left(\frac{U''}{U'''}\right) < 2\left(\frac{U'}{U''}\right) \Rightarrow 3\left(\frac{U''}{U'}\right)^2 > 2\left(\frac{U'''}{U'}\right)$ *i.e.SU* < 0 Also / . . .

$$\pi_2 - \pi_1 = 3\left(\frac{U''}{U'''}\right) - 4\left(\frac{U'}{U''}\right) < 0 \Rightarrow |\pi_2| > |\pi_1|$$

b. $U'' > 0 > U''': \pi_1 > 0 > \pi_2$ with $|\pi_2| > \pi_1 > 0$

From
$$\pi_2$$
:
 $3\left(\frac{U''}{U'''}\right) < 2\left(\frac{U'}{U''}\right) \Rightarrow 3U''^2 > 2U'U''' (or SU < 0)$
c. U'', U''' > 0: $\pi_2 > \pi_1 > 0$ and SU < 0 trivially

d. U", U" <0: $\pi_2 > 0 > \pi_1$ with $\pi_2 > |\pi_1| > 0$

and 3U"2 >2U'U" so SU<0 again Remark I: For U'<0 the permutation $(a \Leftrightarrow b; c \Leftrightarrow d)$, leads to the same conclusion

Remark II: It is easily seen that $\Delta > 0 \rightarrow SU < 0$

Therefore SU<0 is a minimally necessary condition. Although there is a variety of functions verifying this property, like the exponential, the arctangent, or the sin, by far the most studied and well understood are the polynomial ones. In our case, we will see in a subsequent section, where we will show the complementarity of the present study to the classical comparative statics, the unique importance of this distinguished class to the definition of risk. To further stress the role played by the critical points and their stabilizing effects we tackle next a concept
coming from the exact sciences which has proven to be unifying for non-linear Dynamics.

3. SINGER'S CONJECTURE

In the domain of map iteration, May(1976) formulated a hypothesis of the concavity of the function being iterated in order to insure stable convergence. His concern, based on population dynamics, was to generalize the results already known for the quadratic mapping. Since this was a problem which already had been the concern of scholarly pursuit for generations, most notoriously by Cayley in the 19th century, Singer, drawing on the masterwork done by Julia (1917) and Fatou, substituted the negativity of the Schwarz' derivative to the concavity assumption. Taken up by Eckmann and Collet in their book on map iteration (1980) as a minimally necessary assumption, it became the standard in the field of non linear dynamics. The Singer's conjecture generalizes to every polynomial whose first derivative has real roots of any order of multiplicity the negativity of the Schwarz' derivative, already proven for real simple distinct roots.

For the proof we will use a different formulation of the Schwarz' derivative, namely:

 $SU=(U''/U')' - (U''/U')^2$ since we have the identity: $(U''/U')'=(U'''/U') - (U''/U')^2$

(U''/U')=(lr''/r')+(ms''/s')+(nt''/t')=(l/x+a)+(m/x+b)+(n/x+c)

And their derivatives are all negative, therefore (U''/U')' is negative, no matter the number of factors entering in the product defining U' as long as it is finite. Since we can also let l,m,n,... Take all the positive integer values imaginable, we have therefore constructed all possible polynomials with real roots for their derivative and proven the proposition. Q.E.D.

Since $(U''/U')'<0 \rightarrow SU<0$, we have therefore proven the equivalence between the Arrow's risk measure and this functional form of the new solution set.

The importance of Singer's statement is primordial to our purpose since we are dealing with nondecreasing functions. Indeed, in this case, every root of U' is also root of U'', therefore is at least double root. Polynomials with negative Schwarz' derivative have many interesting properties none the least the fact that they are invariant up to Mobius transformation (aU+b)/(cU+d) thereby generalizing the usual linear transformation invariance retained for utility functions in general. This latter is seen as a special case of the subset: ad-bc=1, with c=0. Another pertinent property is the preservation of the cross ratio between 4 points. This leads directly to complete determinacy via three points.

4. COMPATIBILITY WITH COMPARATIVE STATICS

The aim here is to show that replacing two differential equations (brought by setting the local and global measures equal to constants), incompatible by definition, by one differential inequality is perfectly logical if we want to define a curve over the whole field. Our way to proceed is to apply the method of variation of the constants, bringing to bear the Sturm theorem reconciliating the two levels.

In the Small: we have seen that, at first approximation as the variance is small, we reached the following expression for the premium:

$$\pi_2 = 2\left(\frac{U'}{U''}\right) + \sigma^2 \frac{U''}{2U'}$$

In the framework of Mean Variance (Tsiang) usually retained, we see that U"/U' is the coefficient of the variance up to multiplication by a positive constant. Since it is also decreasing, as seen in the proof of Singer's conjecture, Pr Arrow's alternative definition of the local absolute risk measure is perfectly appropriate. We will see that for the asymptotic behavior of the traditional relative measure, this same property is all we need to have a stable convergence. A further remark for this subsection is that the principal term, missing from previous considerations, is 2U'/U", precisely representing systematic risk, after uncertainty is resolved. In order to have a positive premium to account for aversion to risk we should, at first approximation, have U">0, assuming of course U'>0. Assuming for a moment that U"=kU' therefore $U^{"}=k^2U'$ we, by substitution for $U^{"}$: $U^{"}=$ k^2U' whose solution is U'=A cosh kx +Bsinhkx. We retain only the first term for monotonically increasing solutions. The result $U=(A/k) \sinh kx$ is a generalization of the exponential function usually assumed at this local level.

It is clear that the choice of the new premium hinges on the criterion of Maximum modulus among the different possible roots. It has further the virtue of embodying in its expression the qualitative feature of the negative Schwarz derivative. It is easily seen as the solution emanating from this new level of the Taylor series. However, the negativity of the Schwarz' derivative should not be seen as dependant on the choice of the appropriate root. Indeed, as stated earlier, the positivity of the

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discriminant as a condition for the existence of solutions for the binomial is sufficient to guarantee the Schwarz' derivative property. Moreover, even when the variance is small but not identically zero, it is shown that the neglected root is a higher order equivalent to the classical statics, fully compatible with the same property (SU<O), independently from the sign of U"". we assume U'>0 hereafter:

The product of the three roots is: $\mu^2 - 3\left(\frac{U''}{U'''}\right)\sigma^2$

The main part of the product of the roots assumed so far is (the variance being small):

2(U'/U'')[3(U''/U'')-2(U'/U'')] with the pertinent assumption of U'U'''<<U'''

It is clear that, for the variance small enough, the skewness is negligible. It is also a fact that when the second term in the double product is small enough,

we recover the traditional premium $\approx \frac{-3}{6}$

$$\cong \frac{-3\sigma^2 \frac{u}{u''}}{6 \frac{u'}{u''}}$$

$$\pi_0 = \frac{-3\sigma^2 \frac{U''}{U'''}}{6\frac{u'}{u'''} - 4\frac{u'^2}{u''^2}}$$
 { Let U'''<0. Then SU<0 trivially

and we will have risk aversion if U"<0

{Let U"">0 now. Then $(U'/U")>(U'/U")^2$, SU<0 and again we reach the same conclusion. It is remarkable in this case to notice that even if the variance is not small, the effect of a positive skewness is to increase risk aversion.

In the Large: When we take the derivative of the relative measure of risk we get:

 $(-xU''/U')' = -(U''/U') + x(-U'''/U' + U'''/U'^2)$ = $x(U''/U')^2 - U''/U' - xU'''/U'$

Or in terms of decreasing powers of U"/U': a binomial with discriminant $\Delta = 1+4^2xU^{"'}/U'$

Since the usually assumed condition U"">0 leads directly to the positivity of the discriminant we get two roots, only one of them convergent. Indeed we see immediately that U"=0 always gives a Decreasing Relative Risk (DRR) since in this case (relative Risk Aversion=RRA)' has the opposite sign of X i.e. negative by assumption:-X(U"'/U'). therefore U"=0 is between the two roots, hence one root corresponds to U">0 the other to U"<0. We can now read directly the variations of the traditional RRA with the alternative Arrow ARA (Absolute Risk Aversion) and its limits of decreasing behavior on the following diagram: X>0



Nota: IRR= Increasing Relative Risk aversion DRR= Decreasing Relative Risk

IARA= Increasing Absolute Risk Aversion

DARA= Decreasing Absolute Risk Aversion

We verify, by inspecting directly the expression of the solution as a function of the Discriminant, that the only convergent solution corresponds to DARA and to U''>0.

The diagram assumes not only X>0 but also X increasing to infinity. Should we change the direction of convergence of X toward zero, the arrows change directions and the roots' stability as well. For X<0 the reader could verify easily that the same root is still the convergent one although now the sign of U" has changed relatively to the roots. The immediate implication of the change of the sign (U") corresponding to the stable root with the change of sign (X) seems to indicate that a stable solution around X=0 entails an expression of the second derivative negatively proportional to X. It is pertinent at this point to remark that the case X<0 corresponds to debt or insurance since it relates to a negative amount, and therefore that the framework extends the classical analysis to the whole domain of variation.

We will now consider the general solution $(RRA)^{2}=0$ giving, by the same token, the classes of functions either with constant RRA or their asymptotic equivalents when X tends to its boundaries of variation. From the formal expression of $(RRA)^{2}=0$, we get:

 $X[(U''/U')^2-(U'''/U')] = U''/U' \text{ OR } X(-U''/U')' = U''/U'$

(U''/U') = k/X hence $U=(L/k+l) X^{k+1}+C$

With k,L,C parameters.

What we need to show now is the compatibility between this direct formulation of the solution and the previous one stemming from the analysis based on the two roots.

We see first that k=constant is equivalent to a constant discriminant. Since

 $K = XU''/U' = (1 + \text{ or } - \sqrt{\Delta})/2$

Let us set U'=V and $\Delta = 1+4a$, $a=(x^2U'''/U')$. we now have

(1) XV'-kV=0 to be compatible with

(2) $X^2V''-aV=0$

By differentiating (1) and multiplying by X we get: $X^2V''+XV'$ (1-k) =0 substituting kV for XV' from (1) we have

 $X^2v''+k(1-k)V=0$ identical to (2) by setting a=k(k-1). We see then that the same Δ gives two corresponding k (conjugate) related by: K(k-1)=k'(k'-1) or k+k'=1 More importantly perhaps is the question whether we can have a classification of the solutions of (2) as the risk measure U"/U' i.e 'a' changes.

The answer is provided by the famous theorem of Sturm from differential geometry that we state without proof:

Given two differential equations

 $\begin{array}{rll} I & V"-a(x)V=0\\ And & II & W"-b(x)W=0 \end{array}$

Or any interval (X0,X1) where a>b with V(X0)=W(X0)=0 the solutions are such that W(x)>V(x) on the same interval and as long as they are non negative.

Nota: our focus here is on the representation of one individual's preferences and not on the risk comparison between individuals.

The same theorem applies to the local level U""- $k^2U'=0$ when k varies. It is becoming clear why a utility curve for an individual cannot classify him, as far as risk attitude is concerned, v/s another individual over the whole domain of definition, unless these critical points are rejected to infinity. Otherwise we have to accommodate a switch in the classification by intervals. The exponential function fulfills the first alternative, the polynomial the second one.

The Increasing Relative Risk Hypothesis:

We have seen in the first part that the alternative (Arrow) DARA condition was compatible with the existence of a premium at the level two of the Taylor approximation. We have further seen that the same DARA was compatible with the stable root (convergence) for (RRA)'=0. It is legitimate to wonder whether the previous condition induces any information on the variation of RRA near the root. One can appreciate the difficulty from the diagram where the root could be approached from either side (IRR) or (DRR).

Indeed setting the condition of positivity for the discriminant: $U''^2/U' - U''' > 5U'''/3$

By local consideration even at infinity $(X \Rightarrow +\infty)$ we have the following equivalence:

$$X(U''/U') = k X^2(U'''/U') = a = k(k-1)$$

So $XU'''/U'' = k-1$
 $\Delta \pi > 0 \Leftrightarrow X[U''^2/U' - U'''] > 5XU'''/3$
 $= 5(k-1)U'''/3$

In order to have (RRA')>0 all we need is

5(k-1) U''/3 > U''. Assuming U''>0, it is sufficient to have: $k \ge 1 + 3/5 = 8/5$ Q.E.D

In the case of the retained solution set i.e. starting from $X^3/3$ the hypothesis is confirmed.

A Special example

The first example which comes to mind is, of course the simple cubic. Although it has been established that it does not fit quantitavely the hard data of the plateau phenomenon or qualitatively the change of concavity around the origin, its logic is still valid. We will keep it for comparison purposes. $U' = (x - xo)^2$, U'' = 2(x - xo), U''' = 2

The premium becomes: 2U'/U'' = x - xo

The higher level premium is: $\left(\frac{3U''}{U'''}\right) - \left(\frac{2U'}{U''}\right) = 2(x - xo)$

We see clearly the importance of the threshold point xo and the relative value of the amount x.

If we take the next simplest shape fitting qualitatively, we get the quintic (fig.0):

$$U' = (x^{2} - x^{2}o^{2}), U'' = 4x(x^{2} - xo^{2}),$$

$$U''' = 4(3x^{2} - x^{2}o).$$

With first premium = $(x^{2} - xo^{2})/2x$
And second one = $3x(x^{2} - x^{2}o)/(3x^{2} - xo) - (x^{2} - x^{2}o)/2x = (x^{2} - x^{2}o)(3x^{2} + x^{2}o)/2x (3x^{2} - xo^{2})$

We can recall here from St Petersburg that the gambler's behavior has been dubbed as irrational or impulsive in the region after the plateau where U''' > 0. Curiously enough, no such qualifications have been applied to its sister concept of probability. Indeed one is using identical procedure, the stimuli response method to elicit subjective probability from a continuum of supposedly objective one. More importantly one observes the same changes in concavity, on the positive orthant starting from zero and higher amounts. The usual description is to call such psychological process an overestimation of small values (Risk taker) and underestimation of higher ones (Kahneman & Tversky)

We can see that in our model the theory fit the behavioral interpretation precisely due to the introduction of the threshold Xo. Now for small values relative to Xo the theoretical possibility that one takes an insurance premium (and avoid the lottery) could be explained by the fact that the "amount is not worth the gamble". That is a region where both U" and U" are negative. This gives us a first level premium negative and a second level one positive. Keeping in mind that the second one, in absolute value, is always bigger than the first, and will be the dominant one, we can still detect a secondary effect due to the smaller premium. Closer to Xo, when U'" becomes positive, while U" is still negative, the second premium becomes negative. The gambler is more inclined to seek the lottery. At higher amounts (X>Xo), all the derivatives of U as well as the two premiums are positive. However, psychologically, the opposite phenomenon is at work due precisely to the relative position of the stakes v/s the threshold Xo. The decision maker will be a risk avoider because he prefers to assure himself a comfortable certain equivalent comparatively to Xo.

On the negative orthant, where the insurance reflex is relevant, near the origin and by symmetry, we have U">0 but U""<0, therefore the first premium is positive and the second one negative. He will still risk losing small amounts, but will reverse himself when the amount reaches the root of U"". The behavior is symmetrical to the positive orthant case... Indeed we now have a situation with a inflated fear of a loss for which he could be held accountable, thereby triggering his risk aversion reflex. Both premium are now positive since U" still positive and U'" has become so... But the more we approach-Xo the less risk averse the behavior, turning into a risk seeking region below -Xo(U'' <0, U''' > 0) and increasingly so, precisely because once the debt is beyond the accountancy threshold (-Xo) the phenomenon of irresponsibility becomes present (ruin).

This interpretation helps to explain for high Xo, given the same stake X, the phenomenon of selfinsurance. Ironically, similar behavior, but for completely opposite reason (poor enough to afford insurance), finds its explanation here also. From the insurer's point of view, the rationale to enter the contract agreement comes from the empirical observation of the high frequency of occurrence for small losses and the small one (rare events) for the big losses.

In the case where U'=0 (X=+ or -Xo), U''=0 also and the only premium left is equal to μ . Consequently, the skewness becomes the unique relevant factor, independently from the sign of U''' or the value of the variance. Also, when U''=0 without having U'=0, like at the origin, the premium, again independent from the variance, is a function of the skewness and the ratio U'/U'''.

Finally the question of deductibles as well as the problem of portfolio selection would find a satisfactory answer if the RRA was high enough, like greater or equal to three. This follows from some theoretical studies coupled with empirical computation (J.M. Grandmont) and goes to show the adequacy of the degree of the representation chosen. Behaviorally speaking, however, it is clear why a higher deductible induces the imposition of a lower premium by the insurer. We see here the practical importance of knowing the reference point Xo.



The mean risk approach to St Petersburg

Following up on the mean variance approach of Harry Markowitz (1959), Paul Weirich proposes a variant to the expected utility decision rule. His version evaluates an option (O) by separating the utility of the causal consequences from the utility of the risk involved. He then considers a series of elementary gambles. The St Petersburg being the limit of this series. The mth gamble involves the coin to be tossed exactly m times. If the first heads comes on the nth toss, the gambles 2*n dollars. If heads never comes up, the gamble pays nothing. He then formulates a set of seemingly plausible assumptions toward risk in order to insure that the two corresponding partial series. to the consequences and to the risk respectively, have their principal terms converge so fast to each other that the two infinities reach a finite difference.

The chief premiss of the approach is that the small chances for large prizes create big risks. In other terms aversion to risk puts a limit on the attractiveness of gambles. More Picturesquely, there is some number of birds in hand worth more than any number of birds in the bush.

This last image seems to precisely correspond to what the classical literature refers to as the systematic risk that we have formally quantified above.

"Suppose that all firms tend to be profitable or unprofitable together, due, for example to shifts in foreign demand. The investors would like to find insurance against а generally unfavorable development, but they cannot find it by any amount of diversification. There may indeed be individuals or organizations who would be willing at a price to pay compensation for the occurrence of the unfavorable event, but the stock market does not provide any opportunity a mutually for advantageous insurance transaction to occur". (Arrow, 1971, p. 139).

Indeed two important corrolories of the intuitively appealing premiss is that aversion to risk increases with the dispersion of the outcomes, and that the greater the stakes, the greater the rate of increase in risk for subsequent increases in the stakes. Although the mean risk approach does not assume expected utility, it does not precludes it either as P. Weirich point out in a note:

"One might conjecture that the sum on the right hand side of the equation is equal to the expected value of some utility encompassing both the utility of the consequences of O and the utility of a risk involved in O, perhaps the expected value of the utility of O itself, i.e., P(Sn)U(O,Sn), with Sn representing mutually exclusive and collectively exhaustive states of the world independent of the option O. If this conjecture were correct, our mean risk method of evaluation would be compatible with an expected utility method of evaluation. I will not explore this issue here, however".

We will show presently that the main tenets of mean risk method of evaluation could be accounted for in our classical framework.

Since our second level premium is greater, in absolute value, than the one at the first level, and the inclusion of the variance at the second approximation would oblige us to take into account the skewness and solve a third degree equation, for sake of comparison, we will focus on the first level premium with only an extra term corresponding to the variance.

For the stakes big enough, X is large relatively To Xo, hence U">0 and each term of the premium is positive. Therefore aversion to risk increases with the dispersion. Also the principal term is always increasing in X: (U'/U")' > 0, as proven earlier.

Finally, the main point of convergence between the two methods is the unboundedness of the utility function. However, one has to stress that Pratt's approach is rigorously valid only as the variance tends to zero, i.e. near and at certainty. Its limitation comes from the fact that it could only handle a limited number of moments of the distribution. But the main point here is to see the compatibility of the two methods as far as the attitudes to risk are concerned.

More important from our perspective is the fact that we have been able to account for the gambler's behavior regardless of the probability distributions. This seems to fit, together with the introduction of the threshold, the original approach of D. Bernoulli as well as the subsequent derivation of the probabilities from the assessment of the utilities first, assuming that the expected value hypothesis holds. The work of Friedman and Savage (1948) comes immediately to mind. In the same vein, Weibull (1982) shows the existence of the functional form, called concatenation, for the preference function, identical to the relation holding for observable phenomena in physics, in an article starting from the expected utility hypothesis and proving a dual theorem to Von Neuman's.

It might come as a surprise that our result does not use the specifies of the probability concept but rather isolates a phenomenon appearing with everyday pervasive presence of risk. This is made possible precisely because the Pratt's approach leads to the complete resolution of uncertainty. This ubiquity of risk is the raison d'etre of the futures contracts as an extension of specialized risk shifting on debt instruments in Neil S. Weiner (Stock index Futures 1984):

"Although our economics textbooks have remarkably little to say about the matter, nothing is more obvious than the university of risks in the economic system... in a capitalist society, the success of new businesses and the movements of the stock market cannot be foreseen; and above all, technological progress and the development of new knowledge are by their very nature leaps into unknown". (Arrow, 1971 p. 135).

5. EXTENSIONS AND CONCLUSION

The closest resemblance in this field to the concepts we have been putting together comes from Richard Jeffrey's "The Logic of Decision". Although he dismisses the St Petersburg game as a big lie, he clearly sees the need to define a scale with three points instead of two. His utilities, when referring to the lottery are unbounded. More importantly, he is dealing with a world of propositions giving a linguistic flavor to his endeavor. The method he adopts is not causal but constitute a variant from Ramsey's procedure to elicit probabilities from preferences' profiles:

"here, the elementary logical operations on propositions (denial, conjunction, disjunction) do the work which is done by the operations of forming gambles in the "classical" theory of Ramsey and Savage...but here (see chapter 6), the preference ranking of propositions determines the utility function only up to a fractional linear transformation with positive determinant... The classical case is obtained here if the preference ranking is of the sort that can only be represented by a utility function that is unbounded both above and below; and it is shown (chapter 10) that the present theory is immune to the St Petersburg paradox, so that one can reasonably be a Bayesian in the present sense and still have an unbounded utility function. "(Richard C.Jeffrey in the preface of The Logic of Decision'1983)

We also noticed the relevance of Arrow-Pratt notion of certain equivalent in H. Stoll formula for parity relationship between put and call where the missing Risk Premium confirms the market Aversion to Risk.

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Also the connection with Newton method in numerical analysis, where Schwarz derivative was found instrumental in elaborating an algorithm, brings to light the equivalence to Policy Iteration Procedure (PIP) of Dynamic Programming.

A final quote should go to Tsiang:

"The influence of skewness (the third moment) on the expected utility is positive. That is to say, a positive skewness of the distribution is a desirable feature, and other things being equal, a greater skewness would increase the expected utility. This is not a result peculiar to the assumption of a negative exponential utility function, but may be shown to be a general pattern of behavior towards uncertainly on the part of all risk avert individuals with decreasing or constant absolute risk aversion with respect to increases in wealth"...

"Thus if we regard the phenomenon of increasing absolute risk-aversion as absurd, we must acknowledge that a normal risk-avert individual would have a preference for skewness, in addition to an aversion to dispersion (variance) of the probability distribution of returns. It is interesting to note that Harry Markowitz once remarked that "the third moment of the probability distribution of returns from the portfolio may be connected with a propensity to gamble". Nevertheless, as we have shown above, skewness preference is certainly not necessarily a mark of an inveterate gambler, but a common trait of a risk-aversion. I cannot, therefore, go along with Markowitz in taking the view that since gambling is to be avoided, the third moment need not be considered in portfolio analysis"...

"Anyway, skewness preference must be fairly prevalent pattern of investor's behavior, for modern financial institutions provide a number of devices for investors to increase the positive skewness of the returns of their investments, for example, the organziation of limited liability joint stock companies, prearranged stop-loss sales on the stock and commodity markets, puts and calls in stocks, etc., which otherwise would perhaps not have been developed". (Tsiang, 1972, pp. 358 – 360).

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Improvement of the response time in an Open Source audioconference architecture based on SIP Multicast implemented with JainSIP, JainSDP and JGAP libraries

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ABSTRACT

Group services like the audioconference require a minimum level of quality of service for multicast sessions on both control and media plane. This work proposes a new overlay multicast architecture based on SIP extensions and a genetic algorithm. The architecture consists of a SIP Extender client (SE), a Multicast Gateway Agent (MGA) and a Multicast Manager (MM). The SE receives information about the most adequate MGA for it determined by a genetic algorithm inside the MM, then connects the chosen MGA and maintains connection with the MM itself. The genetic algorithm is implemented with JGAP(Java Genetic Algorithm Package) libraries. The SE and MGA are programmed with JainSIP and JainSDP libraries which contain Java structures associated with the SIP protocol and session description. Some experiments over UTP wired and WiFi IEEE802.11n network were performed. Partial results with static and dynamic MGA selection show that, if we compare the joining and leaving time measured inside a station containing SE client programmed with JainSIP and JainSDP libraries versus SJphone proprietary client, the software engineering may have more influence than the medium access method in the response time for a potential group member. Even more, the genetic algorithm at the MM minimizes the response time at great scale.

Keywords: Open source, Audioconference, SIP Multicast, JainSIP

1. INTRODUCTION

Nowadays voice, video and data traffic are getting integrated in the same networking platform. The design of such architecture has to take into account the applications to be deployed considering the highest layers of the TCP/IP model [1]. One of the most demanded applications is the audioconference between groups, and its improvements is being done over applicative layer. An adequate level of quality of service is required for these applications, like a low response time for joining and leaving group member, and this can be achieved through the use of multicast [2][3]. There are three types of multicast: IP multicast, Overlay Multicast (OM) and Application Layer Multicast (ALM). IP Multicast is used in IPTV with the use of protocol IGMP (Internet Group Management Protocol) for IPv4, or MLD (Multicast Listener Discovery) for IPv6 [4]. The second approach uses the end systems and intermediate proxies to form the trees [5]. In the third approach the end systems are completely responsible for the creation and destruction of trees [6].

A new architecture for audioconference based on overlay Multicast with several clients has been designed and implemented [7]. Such architecture consists of an extended SIP [8] client, a multicast manager and a MGA (Multicast Gateway Agent). The multicast manager module has been enhanced with APIs JainSIP [9] and JainSDP [10] open source libraries. At great scale it is possible that the response time depends not only on the SIP timers and delays [11] of the network but also on the process to find the best multicast trees inside the multicast manager. That is the reason why we propose the use of a genetic algorithm. Three test groups were mounted to compare the response time over UTP wired versus over WiFi, and to analyze a an isolated JGAP based genetic algorithm at MM.

In section 2, we explain the relationship between SIP protocol and multicast. Then, in section 3 we describe JainSIP and JainSDP libraries for SIP programming. After, in section 4 we explain the relationship between genetic algorithms, open source and multicast, and describe JGAP libraries. In section 5 we explain details of the new architecture. In section 6 we explain the experimentation done in the three tesbeds to compare them. In section 7 we show the results of measured response time on the new architecture, and finally in section 8 we explain the conclusions and perspectives.

2. SIP AND MULTICAST

IP multicast can be used with SIP as a discovery-like service for a simple host, where it sends a simple requests to a group of homogeneous servers, and processes the response of only one of them. This functionality is mainly used for registrations with

multiple servers[12]. Some work has been done since 1998 to allow multicast and unicast conference sessions with SIP. In that year, an article published by both Dr. Schulzrinne and Dr. Rosenberg show how IP multicast conferences could be established[13]. This approach presents the drawbacks of IP multicast in a LAN or WAN. It forces the network administrator to install mrouters, and switches that support dynamic group management protocols like IGMP snooping. As a consequence, two more approaches are used: Overlay Multicast and Application Layer Multicast. Overlay Multicast permits that proxies are located in the center of the trees topology. In the ALM approach, the end systems are responsible for the creation, maintenance and termination of groups multicast groups. A new architecture named SIP Multicast for audioconferences based on Overlay Multicast was designed at small scale in 2009 [7]. The present work improves the initial prototype by introducing additional software engineering APIs, and optimization, considering also its performance over WiFi.

3. SIP AND OPEN SOURCE

Several projects have been created by the community supporting SIP protocol. For instance, ASTERISK[14] and its precompiled version ELASTIX, consists of an IPBX server that provides basic signaling functions and more complex features like centralized conference, instant messaging, presence, redirectioning among them. Some projects located at the end systems as softphones like JITSI were programmed with Java language. On this specific case, JITSI is based on open source libraries JainSIP (JSR032) and JainSDP (JSR031) created by NIST (National Institute of Standards and Tecnology). Other libraries are SIP servlets (JSR289), SIMPLE instant messaging (JSR165) and Jain SLEE (JSR22 and JSR240). This work is based on JainSIP and JainSDP libraries.

JainSIP

JainSIP (Java APIs for Integrated Networks SIP) is a Java standard for a low-level SIP interface. It provides access to SIP at the lowest level. Its programming constructs represent concepts such as messages, headers, parameters, ports, and IP addresses.

JainSDP

Defines a Java Interface to facilitate manipulation of SDP (Session Description Protocol) which describes SIP sessions within requests and response messages.

4. GENETIC ALGORITHMS AND OPEN SOURCE

Several open source projects have been created to implement metaheuristic methods. In the area of genetic algorithms one of the best documented projects is JGAP (Java Genetic Algorithm Package).

JGAP

Based on Java language, JGAP contains classes and methods that represent the natural evolution[15]. The programmer defines basic parameters like: number of population members, number of generations and genetic operators (mutation, crossover). It is possible to add new genetic operators and define a customized fitness function. Some studies suggest the use of concurrent programming for a faster execution.

GA AND MULTICAST

Multicast technologies are based on the creation of trees represented by graphs. Optimization techniques can be employed to generate and choose the most adapted tree according to the problem. Genetic algorithms are under research just to find the best graph. Its velocity depends on the software engineering and design of the algorithm.

GA and IP Multicast: Bhattarchya & Venkaterwaram (2005)[16] proposed a new IP multicast routing scheme based on GA. Results showed that simulations of such

metrics, topologies and number of nodes ranging from 32 to 1000, yield better performance than existing multicast routing schemes.

GA and Overlay Multicast: Wan & Gang (2008) [17] proposed a heuristic genetic algorithm for multicast overlay network link selection that reduces the overlay network links by using fast converging speed and stabilization with simply operation.

GA and Application Layer Multicast: Pen & QionGhau (2005) [18] proposed a novel application that includes load balance constraints at both application and network layer within an adapted fitness function.

5. SIP MULTICAST ARCHITECTURE

The new architecture SIP Multicast based on SIP protocol, with Overlay Multicast and groups management consists of a SIP extender (SE), a Multicast Gateway Agent (MGA) and a Multicast Manager(MM).



Fig. 1 SIP multicast architecture

SIP Extender-SE: this component permits to work with SIP extended signaling. It adds an additional header field that indicates the use of Overlay Multicast. It also converts back extended messages with SIP multicast into SIP conventional ones.

Multicast gateway Agent-MGA: it interprets the extended SIP multicast messages and responds to the SE user agents. It fills out and reads information from an Applicatve Multicast Table that contains information about the user agents associated with their respectives SIP extenders.

Multicast Manager-MM: consists of the brain of the SIP multicast architecture and works only on the control plane. A human operator can choose whether a specific user agent will solicite its inclusion or exclusion for an audioconference if a static configuration is done. In the automatic modality, it can calculate the optimal topology. It means to find out which MGA must be connected with the SIP extender.

SE and MGA area programmed based on JainSIP and JainSDP APIs. MM is programmed with JGAP APIs and multithreading.

6. EXPERIMENTATION

We implemented three testbeds just to measure joining time , and leaving time on the system fixed vs wireless, and processing time within MM at great scale.

Joining Time

We used two criteria as Joining time:

$$JT1 = T_2 - T_1 \qquad \qquad \text{Eq.(1)}$$

Where:

JT1: Joining Time

T₂: Instant when the first media packet arrives

T₁: Instant when the INVITE extended message is sent

$$JT2 = T_3 - T_4 \qquad \text{Eq.(2)}$$

Where:

JT2: Joining Time

 T_3 : Instant when ACK extended message is sent T_4 : Instant when INVITE extended message is sent

Leaving Time

We used two criteria as Leaving time:

$$LT1 = T_6 - T_5$$
 Eq.(3)

Where:

LT1: Leaving Time

T₅: Instant when last media packet arrives

 T_6 : Instant when BYE extended message is sent

$$LT2 = T_7 - T_8 \qquad \text{Eq.(4)}$$

Where:

LT2: Leaving Time

 T_8 : Instant when BYE extended message is sent T_7 : Instant when OK extended message is received

Processing Time

Processing Time is considered as follows: PT = ET - ST

Where:

PT: Processing Time measured with TimeMesurer software

Eq.(5)

ST: Starting Time before applying GA

ET: Ending Time after applying GA

Testbed 1 Joining and leaving Time fixed network:

Consists of two softphones including SIP Extender (SE), a PC with MGA and MM modules inside, and a router WiFi WRT160N. MGA is implemented with JainSIP and JainSDP. MM is implemented with Java. A genetic algorithm based on JGAP was isolated. All terminals are connected via UTP cable (Fig. 2).

TimeMeasurer software was used to calculate PT. The softphones studied are JITSI and SJphone. WiresharkTM was used just to get JT1, JT2, LT1 and LT2.

Joining Time and Leaving Time are measured 10 times by using Wireshark software. This testbed was located in a closed room.



Fig. 2 Fixed network testbed

Testbed 2 Joining and leaving Time WiFi: consists of two softphones + SIP Extender (SE), a PC with MGA and MM modules inside, and a router WiFi WRT160N. MGA is implemented with JainSIP and Jain SDP. MM is implemented with Java. A genetic algorithm based on JGAP was isolated. MGA and MM are connected to the router via UTP cable, and the terminals with the softphones via WiFi IEEE802.11n (Fig. 3). The softphones studied are JITSI and SJphone.



Fig. 3 Wireless network testbed

Joining Time and Leaving Time are measured 10 times by using Wireshark software. This testbed was located in a closed room.

Testbed 3 Processing time in isolated MM: consists of the GA searching operation within MM based on JGAP with multithreading [19]. The population contains 80 individuals each one formed by a chromosome of one gene with maximum 32 bits (Integer). The initial population was randomly created and 500 generations were employed on the evolution. The best individual was calculated 10 times with 5,12,19,26 and 32 bits gene representing a graph that contains a potential MGA. We emulated the process of selecting the best MGA by using

the fitness:

$$F = \frac{100}{D_{SM} + D_{MGM} + D_{MMS}}$$
 Eq. (6)

Where:

F: Fitness Function of GA.

 D_{SM} : Weight representing lowest bandwidth of link between SE and potential MGA.

 D_{MGM} : Weight representing lowest bandwidth of link between potential MGA and MM.

 $D_{\mbox{\scriptsize MMS}}$: Weight representing lowest bandwidth of link between MM and SE.



Fig. 4 Processing Time testbed

7. RESULTS

Joining Time JT1 and Leaving Time LT1

Considering the measured variable JT1 (Fig. 5), it can be seen that its highest value corresponds when JITSI software was employed mainly, with UTP connection or with WiFi access medium. The central PC contained modules MGA and MM. MGA location is predefined on this case without a genetic algorithm in a static configuration.



Considering the measured variable LT1 (Fig. 6), it can be seen that its highest value corresponds when SJphone software was employed mainly, with UTP connection or with WiFi access medium. The central PC contained modules MGA and MM. MGA location is predefined on this case without a genetic algorithm in a static configuration.



Leaving Time LT1 per session

Joining Time JT2 and Leaving Time LT2

Considering the measured variable JT2 (Fig. 7), it can be seen that its highest value corresponds when SJphone software was employed mainly, with UTP connection or with WiFi access medium. The central PC contained modules MGA and MM. MGA location is predefined on this case without a genetic algorithm in a static configuration.



Considering the measured variable JL2 (Fig. 8), it can be seen that its highest value corresponds when SJphone software was employed mainly, with UTP connection or with WiFi access medium. Two peaks were presented with WiFi technology. The central PC contained modules MGA and MM. MGA location is predefined on this case without a genetic algorithm in a static configuration.



The Fig. 9 shows the average JT1 and JT2 values.



In Fig. 9 we can see that average value of JT1 is higher with JITSI which uses JainSIP and JainSDP. However, it can be seen that JT2 has its lowest value with JITSI and WiFi. We can note that, software engineering has more impact than access medium for JT1. It is possible that access medium has more impact than software engineering for JT2; but it can not be assured for the scenarios studied because the average differences are not so high.

Leaving Time LT1 and LT2 comparison



In Fig. 10 we can see that average value of LT1 is higher with SJphone. However, it can be seen that LT2 has its lowest value with JITSI and UTP. It is possible that access medium has more impact than software engineering for LT2; but it can not be assured for the scenarios studied because the average difference is not high.

Processing Time with GA

Considering the measured variable PT (Fig. 11) in an AG within isolated MM module, we can notice that PT is decreased from $2^{5}(32)$ through 2^{26} (67108864) potential MGAs. For $2^{32}(4294967296)$ potential MGAs the PT is also high.



As the number of potential MGAs is increased until 2^{26} (67108864) for a multipoint audioconference, a lower PT would produce fewer retransmissions of SIP extended messages, so improving JT1, JT2, LT1 and LT2 at great scale with UDP protocol. In that case SIP messages delays are higher that 500 ms by default in provisional responses.

8. CONCLUSIONS AND PERSPECTIVES

On the scenarios studied for SIP multicast architecture, software engineering has more impact than access medium if we compare the open source JITSI made with JainSIP and JainSDP versus the proprietary software SJphone. If we include a genetic algorithm made with JGAP inside MM, there would be SIP extended messages retransmissions as processing time would be higher than 500 ms which is comparable to the default value of maximum delay in provisional responses if UDP protocol is employed.

However, if we increase the number of potential MGAs from 2^5 (32) through 2^{26} (67108864) the processing time within MM by using the genetic algorithm is decreased, and so the probability of existing SIP extended messages retransmissions.

If we choose criteria JT1 and LT1 based of media and control plane to study response time, it permits discriminate more easily the impact of software engineering versus access medium than if we use criteria JT2 and LT2 based only on control plane.

The future work focuses on inclusion of the genetic algorithm made with other programming languages within MM, the study of the SIP Multicast architecture with several SEs by using a simulation tool, the behavior of the architecture in high congestion scenarios at great scale with WiFi, and study of retransmissions of SIP extended messages over both UDP and TCP transport protocols.

9. ACKNOWLEDGEMENTS

Tha authors thank to the Consejo de Desarrollo Científico y Humanístico (CDCH) of the Universidad Central de Venezuela for the Budget assigned to the project: "Mejoramiento de arquitectura para servicios multimedia basada en multidifusión IP" under the identification PI-08-7820-2009/1.

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Development of Scammed Posts Detector:

A Case Study of Pet Scammed Posting

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ABSTRACT

This paper presents a research on scammed posts detector which focused on pet scammed posting detection. The research was motivated by the unawareness of pet lovers and owners on the pet scamming activities over the internet. Additionally, the current scam detectors are not able to notify the user on the potential pet scam posts they are dealing with. The objective of the research is to develop an application to automatically identify and alert the user on the potential pet scammed posting as an extension to dear current email system. The scope of the research are online pet advertisements and email communications between victims and scammers. Preliminary investigation on real pet scammed emails, experiences of the real pet scam victims and the public awareness regarding pet scams have been conducted to support the research development. Pet details, hardship of the family, obstacles faced and victim details are among the patterns extracted in the collection of real pet scammed emails. The system is tested against the human baseline and reached up to 86% of accuracy.

Keywords: Pet Scammed, Text Mining, Artificial Intelligence.

1. INTRODUCTION

Pet scams are one of the popular internet scams today. Pet scammed posting is a fake posting about pet sales or adoptions in the online auction sites. The pet sales or adoptions normally involve rare and exotic breeds such as Bengal cats, Beagle dogs and Macaw parrots that do not exist. The scam advertisements are posted in real websites and the dealing between the scammer and potential victim is done through the emails. Email communications are used to prevent the website administrator from tracing their illegal activities. The victims of pet scams are mostly the exotic pet lovers who are looking for adorable pets at a lower market price or pets which are looking for good home. The number of pet scams victims aroused due to the lack of knowledge and awareness on the scamming activities. They tend to commit to offers that are difficult to resists and sounds too good to be true. The Internet Crime Complaint Center (IC3) in the US has firmly established its role as a valuable resource for both victims of Internet crime and law enforcement agencies investigating and prosecuting cyber crime recently reported that they processed 262,813 complaints in 2013, representing more than \$781 million in losses mostly in the classified advertisements¹

Our literature found that the scammers claimed to give away the pets because of a family hardship such as relocation, death of pet owners, change of climate, etc [13,14]. Example of questions posted by pet scammers is shown in Figure 1.

> Are you married?,,,,,,,,,,,,,,,,,, Do you have kids?,,,,,,,,,,,,,,,,,, Have you ever kept a puppy?,,,,, Where are you located?,,,,,,, What do you do for a living?,,,, How soon do you want these puppies?,

Figure 1: Example of Questions in Pet Scams

As far as our knowledge is concerned, there is no automated online scammed posts detector which tailored to online sales in existence. Current scams detector like the Scam Detector App [1] provides only a guideline on how to avoid scammed posts with real examples but is unable to notify users when they might be involved in potential scammed deals. The main effect of pet scammed deals is a huge monetary loss as reported by the victims [2]. Money lost in internet crimes hits a new high last year, topping about \$240 million, according to a government report showing increases in scams including pet scams [11]. As in the pet scammed cases, the scammers whom claimed to be resided in the other side of the world than the victims, offer some pets at very low prices (some are even free for adoptions) but requested the victims to pay for the shipment cost of the pets. The target victims are those countries in the world which has been statistically reported to have a high number of pet lovers such as in the United Kingdom [3], United State [4], Australia [5] and New Zealand [6].

Hence, the objective of this research is to develop an automated scammed posts detector which studies on pet scammed related cases. The scope of the research is to detect potential scams via the email communications between the scammers and the victims. The research takes a supervised learning approach which the categorization of the emails is based on the collection of real pet scammed emails. The outcome of the research is an extension in the email tool as an

¹ http:// www.ic3.gov

additional feature for email users to automatically removed pet scammed emails.

2. LITERATURE REVIEW

Statistically, more than half of the people in the UK keep a minimum of one pet and this has shown that they are pet lovers [3]. It is about 6.6 million dogs and 7.7 million cats is part of British household. In addition, in United State (US), 53.4 million U.S. households with more than one pet reported for 2012 [17]. There are about 95.6 million and 83.3 million of the number of owned cats and dogs respectively in US. In other countries such as Australia and New Zealand, 63% of the 7.5 million households own pets [18] and 68% of the households own at least one pet [19] respectively. Based on these figures, majority of the countries' household own at least a pet and there are exposed to the potential of pet scams risks. Meanwhile, the internet scams cases aroused from 100,000 reports per year to nearly 300,000 reports per year from 2005 to 2009. The monetary loss due to these is accumulated to exceed \$300 million per year [10]. The statistic has shown that online users especially pet lovers have low scam awareness and ability to identify potential scams. This situation has motivated us to provide a solution to protect the online users.

Artificial Intelligence (AI) is a science that has defined its goal as making machines do things that would require intelligence if done by human [7]. Solutions built on AI technologies can help the users to detect fraudulent cases from the examples of previous fraudulent cases learnt by the system. It takes a machine learning approach that requires the understanding and manipulation of text as it deals with email communications. Text processing research uses Natural Processing Language (NLP) techniques to pre-process the text and extract the frequent scammed words known as the *keyword* [8].

Since to date, there is no existing research found to build a solution for pet scams, the research explores and studies research related to scammed email detection, the methods and results. Alireza et al. [12] categorized emails as scams, spams and hams as shown in Figure 2. Scams are defined as illegal emails, spams are the legitimate emails and hams are those emails exchange between users.



Figure 2: Email Categorization [12]

Among the popular methods in spam detection is to use the features of emails and frequency of spammed words as described by Pfleeger and Bloom [21]. This research is also referred as phishing email detection. Chandrasekaran et al. [22] classifies emails based on two structural attributes embedded in the email header: 1) Structure of email subject line and 2) Structure of email greeting in the email's body. Using a statistical method known as Support Vector Machine (SVM), the research attained an averaged on 85% accuracy on 5 series of experiments. Other methods include Logistic

Regression (LR), Classification and Regression Trees (CART), Bayesian Additive Regression Trees (BART) and Artificial Neural Networks (ANN) as critically reviewed by Abu-Nimeh et al. [23]. There are existing tool for scammed email detection for both research and commercial use such as the PhishCatch [16] but none them explored the pet scams related emails.

This research adopted a non-binary classification of scammed emails by detecting the fraudulent patterns that are learnt in the collection of real scammed emails [9] and a simple mathematical calculation. After a successful training, our proposed system is able to label the emails into four categories – *Surely Scam, Scam, Potential Scam* and *Not Scam.*

3. PROPOSED METHODS

Data Collection

There is no publicly available dataset related to pet scams. Hence, we compiled our data based on the pet scammed emails published in a personal blogs, awareness websites and those that have been shared in forums by the victims. A total of 50 pet scammed emails have been compiled for our experiments. Additionally, to support the case study methodology, interviews are conducted with known real victims to learn their experiences and study the whole processes that resulted to monetary loss [20]. An example of the email with the potential scammed keyword based on frequency in other emails is shown in Figure 3.

ello,
y name is kerry.
am actually a mother of Luis(my lovely late 14 years old son) ,he
assed away last two weeks in a car accident with my lovely husband.
nave weep until i do not know what else to do but to move along with
ctually i have 2 Maltese puppies (male / female) my
usband bought for my late son some months ago.
ney are now grown but my humble son whom i love so much just passed
way and i am also disable due to the accident of which i am on a
heel chair ,so i really need a good home for the puppies.
really do not have the strength and means to take <u>care</u> of the puppies.
ote: that I'm not selling this puppies, but
fering for adoption. I want the best for the puppies, so
search of a pet lovely and caring home.
ease can you tell me more about yourself?
interested, hoping to read from you.
nanks.

Figure 3: An Example of Pet Scammed Email (Frequent Keywords are Underlined)

The interview discovered the following pet scammed chronology. The communications are done through email between scammers and victims.

- 1. Scammers shared brief story about the pets to shows how lovely the pets are.
- 2. Scammers post some lovely photos of the pets.
- 3. Scammers shared the story about the hardship of his or her family to grab the attention and sympathy of the victims.
- 4. Scammers asked the geographical details of the victim's location.

- 5. Scammers proposed for door-to-door shipping and will charge the victims for the 'shipping fee'.
- 6. Victims will bank-in the amount of money requested.
- 7. Victims never received any pet delivery.
- 8. Scammers' contacts are no longer accessible.

A full and original email communication is shown in **APPENDIX** for further reference.

System Architecture

The system architecture is shown in Figure 4. It consists of several components. Our solution is proposed as an extension to the web browser which will appear as an icon in the user email's toolbar. It serves as an additional feature to the ordinary email to automatically filter the pet scammed emails. The Pet Scammed Detector filtering engine is built on Visual Basic and link to the list of keywords database. This database compiles all potential per scammed emails.



Figure 4: System Architecture

The flowchart of our proposed system is depicted in Figure 5. The raw text in email is pre-processed using standard NLP techniques, tokenized into vector of words before they get compared with the keywords in our database. Matched keywords are then calculated for its frequency values and compared against some threshold. The thresholds to identify and classify scammed email are based on the techniques that have been explained briefly in the next section.



Figure 5: System Flowchart

Classification Methods

The collection of 50 emails is automatically sifted and frequency of each word is counted for each email. The result generated a maximum and a minimum frequency of the pet scammed keywords which are 32 and 5 respectively. The number between maximum and minimum frequency of those keywords is considered the range of the data set using Equation 1.

$$Range = Max - Min \tag{1}$$

We classified the emails into four different categories - *Surely Scam, Scam, Potential* Scam and *Not Scam.* The *Range* obtained in Equation 1 is divided by four, which is the number of email categories as shown in Equation 2.

$$Size = Range / Categories$$
 (2)

The statistical information of pet scammed email collection is summarized in Table 1.

Table 1: Characteristics	of Pet Scammed	Email Collection
--------------------------	----------------	------------------

Total Email	50
Maximum Keyword	32
Minimum Keyword	5
Range	27
No. of Categories	4
Size	6.5

The four categories are ranked based on the frequency score values or the number of keywords extracted in an email as introduced in [9]. The frequency distribution table is shown in Table 2.

No. of Keywords	Categories	Lower Boundary	Upper Boundary	Midpoint	Percentage of Categorization (%)
6 – 11	Not Scam	5.5	12.5	8	< 38
12 – 18	Potential Scam	12.5	19.5	15	> 37 and < 59
19 – 25	Scam	19.5	26.5	22	> 68 and < 81
26 - 32	Surely Scam	26.5	32.5	29	> 80

 Table 2: Frequency Distribution of Pet Scammed Email

 Collection

The percentage of the email categorization is calculated using Equation 3.

Percentage of
Categorization
$$= [(Keyword + 1) * 100] / Max.$$
 (3)

The example of the calculation for the highest percentage of *Not Scam* category is exemplified below:

Keyword = 11

Max = 32

Percentage of Categorization = [(11 + 1) * 100]/32 = 37.5%We have compiled 66 common keywords related to pet scams from the 50 collected emails. Some of the keywords in our database are shown in Figure 5. The database considers all the variation of words for every lemma (root word). For example, the word die has four variations – *die, dies, died* and *dead*. This is important as the classification is highly dependable on the string similarity of the keyword search. Lemma has been experimented as the best form for document retrieval as shown by Zukerman and Raskutti [15].

🔲 database - No 💷 💷 🗾	3
File Edit Format View Help	
<pre>mission/ missionary/ monthly/ moved/ name/ nigeria/ number/ occupation/ old/ pictures/ relocate/ relocated/ relocated/ relocating/ sex/ shots/ stck/ temperament/</pre>	*
temperature'/ time/ transfer/ transfered/ unfortunate/ vaccinated/ vaccination/ vaccinations/ vet/ veterinarian/ volunteer/ weather/ work/ yourself/	н
1	-

Figure 5: Pet Scam Keywords

4. EXPERIMENTAL RESULTS

The system prototype is built using Visual Basic 2010 Express Edition tool and the interface is shown on Figure 6. It is proposed to appear as an extension or additional feature to the current email interface. Once a suspicious scammed email is identified, user will click on the Pet Scam Detector button to get the email classified. An alert will be displayed to user with different colours to show the warning level of the potentially scammed email/



Figure 6: Pet Scammed Detector Interface

The system is evaluated using 50 unseen emails which include both the pet scammed and legitimate emails. The results are shown in Table 3.

Table 3: System's Generated Email Categorization

No. of Keywords	Category	No. of Emails
1-11	Not Scam	5
12-18	Potential Scam	21
19-25	Scam	17
26-32	Surely Scam	7

These automated generated results are then compared with the built-in string similarity matching algorithm in Microsoft Words and manual string similarity matching by five human experts for its accuracy. Partially, the results for five emails and their comparison are shown in Table 4. The shaded cells represent inaccurate results.

Table 4: Accuracy Test Results

DE	FECTOR		El			E2			E3			E4			E5	
DE	TEC TOR	W	96	S	W	96	NS	W	96	NS	W	96	SS	W	96	NS
P	et Scam letector	12	67	1	4	22	1	4	22	1	18	100	7	6	33	1
M	icrosoff Word	12	67	1	4	22	1	4	22	1	18	100	1	6	33	1
H	uman 1	11	61	1	4	22	1	4	22	1	17	94	1	6	33	1
H	uman 2	12	67	1	4	22	1	4	22	1	18	100	1	-5	28	1
H	uman 3	12	67	1	4	22	1	4	22	1	18	100	1	6	33	1
H	uman 4	12	67	1	4	22	1	4	22	1	18	100	1	6	33	1
H	uman 5	13	72	1	-5	28	1	4	22	1	18	100	1	6	33	1
R	ESULT	7	1	100	8	6	100	- 10	00	100	1	36	100	8	6	100

Legend:

E1-E5 = Email 1 to Email 5 respectively. W = Matched Keyword S = Scam NS = Not Scam SS = Surely Scam The overall results are visualized in Figure 7. The accuracy is 86%. The 14% inaccuracy rate was contributed by human errors in classifying the emails manually. The nature of pet scammed emails to be very lengthy and linguistic thus making the manual matching procedure with the long list of keywords in the database a cumbersome task.



Figure 1: Total Accuracy for 50 Emails

5. CONCLUSIONS

The paper presents a technique to classify scammed email related to pet scams. The classification method has been successfully demonstrated on a Visual Basic application as an extension in the email application. The accuracy test has shown that the system is able to categorize scammed emails at fairly accurate rate. Our future development includes the detection of legitimate web contents that deal with pets. This will require the automated checking of the domain name address of the website, the validity of the posted images on the websites and the existence of the contact numbers.

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APPENDIX

Email 1:

Thanks for your mail regarding my kittens, they are still available to any one prepared to provide them with enough care and love, where they will be well spoil with all their need. they are 12 weeks old and are very good with kids and other pets. Very playful love to play around with toys and kids, they are health guaranteed and registered, vet checked. They are up to date on all their shots and will be coming along side with health papers and vet records.

The reason why i am giving them out to any lovely and caring home is because working hours are too much for me and it gives me no time to take care of them and moreover, they use to belong to my late daughter who just died in a car accident some months back. Being a single mum who just lost her only child, it has really been hard for me to take care of them and offer them the love they used to have. Due to all this and advice from some friends i work with, i have decided to give them out for adoption to a family where they will be well taken care of and treated with much love and care as my daughter use to do.

Since you are interested in getting them , i am willing to give them to you but you have to first assure me that you will take good care of them and that you will send their pictures to me monthly so that i can see how they are doing in their new home. i will like to ask you some question because i believe it is correct to know the family wanting to adopt these lovely kittens . I do hope you can answer me the following: -do you have kids? -are you a breeder? -do you have other pets? -where are you located? -how soon do you want them? -How can i be sure you will take proper care of them? -Will you be interested in the male or female or both ?

I sincerely hope you are not angry with all the questions i asked. I am just doing this because i really want these kittens to get into good hands. So many people are seeking to adopt them but i need to be confident on whom am given them to. Please note that the above questions are important and thus you must answer every one of them. If not i am afraid i cannot let you have these kittens. So please tell me more about yourself and family.

Thanks and have a great day.

Email 2:

Thanks for keeping in touch, and for accepting one of my kittens as part of your family. I will look for a cheap pet delivery agency, that will transport and safely deliver the kittens to your door step. For safety and any unforeseen eventuality, I will register the kittens in a reliable agency that will issue a valid paper of proof during The movement .So do not worry the kittens will be shipped safely to your home.

These kittens are very friendly and get along with other household pets They are very good indoor and out door animals. they also love cuddles and will be great with your kids. As the distance keeps us apart, We will be entitled to use a pet delivery service you will pay only for the delivery to you which will cost you **800MYR** So that the kittens will be transported and safely deliver to your home address.

I will register the kittens for delivery to your home address and I will take care of the registration fees and also the transfer of ownership papers from my names to you name okay. So, you will pay only **800MYR** for the delivery of the kittens.

Note that you will have to pay this money directly to the agency and they will transport the kittens safely to your home address. I was told the agency will use the money for the following:

-To buy the flight ticket -vaccination and medical checkup -approval and transfer of ownership certificate -quarantine and crate. so all this must be validated before they can do the delivery to you So you will have to pay the 800MYR to them before

delivery to you So you will have to pay the 800MYR to them before delivery can be done to you

Also i was told by the agency that , after i have placed the kittens with them , the agency will contact you through phone and email to inform you that there kittens are with them , for you to confirm your address details (since they will be doing a home delivery to you) ,how to do the payment (since you will have to pay 800MYR to them before delivery is done to you) and finally they will provide you with a tracking code with which you will have to track the kittens online at their website to be sure that the kittens are with them and awaiting delivery to you. So if you are okay with all this kindly get back to me with the following information: Your full name? Your home address? Your home number both house number and mobile number ?

Your ZIP code? Your City?

With this information I will process the transfer of ownership papers of the kittens. I will register the kittens soonest for delivery to you .Since I have already prepared for the kittens for delivery I was told that if I register the kittens at the agency, they will deliver the kittens the same day. Because it will be transported by an airplane with a few hours delivery .

I will let you know what the kittens needs later ,the kittens will be coming along with the following basket with what to eat, toys and clothing their food menu. Also do promise to send me update of pictures with you and the kittens and also send me one when you receive the kittens.

INVITED ARTICLES

"you can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future." Steve Jobs

The following articles, included at the end of the post-conference volume of the proceedings, are related to events organized in the context of the conference that did not require the presentation of a previously written article. Among these events were the plenary and the conversational sessions, which were video recorded. The respective videos were posted at http://iiis.org/Videos2014.asp?seasson=summer.

The invited articles related to the plenary keynote speakers who accepted to write an invited paper associated to his/her invited plenary address are the following:

- Knowledge Integration and Inter-Disciplinary Communication in Action Research by Dr. Heidi Ann Hahn
- A Discipline-Independent Approach to a Higher Cognitive Pedagogy by Professor Russell Jay Hendel
- Anticipating Serendipity, Preparing for the Unexpected by Professor Thomas Marlowe
- The Smarter Planet: Built on Informatics and Cybernetics by Dr. Fred A. Maymir-Ducharme and Lee A. Angelelli
- Fostering Interdisciplinary Collaboration to Improve Student Learning by Professor Ronald A. Styron, Jr. and Dr. Jennifer Styron
- An Inter-Disciplinary Language for Inter-Disciplinary Communication: Academic Globalization, Ethos, Pathos, and Logos by Professor Marta Szabo White

Two participative panels, which were held in the format of conversational sessions, generated the following invited papers where authors combined 1) the information they apprehended and/or the motivation they got from the panel and the participative audience, and 2) their practice-based reflections, in order write their respective invited papers:

- The participative panel on Effective Means for: 1) Inter-disciplinary Communications and/or
 2) Transferring Knowledge to the Society at Large, generated the following invited articles:
 - A Missing Key Stakeholder in Curriculum Design and Development Conversations: A Brief Reflective Perspective by Dr. Masengo Ilunga
 - *Potentiality and Limitation of an Interdisciplinary Work* by Professor Leônidas Conceição Barroso
 - The Interdisciplinary Colloquium in Teacher Education by Dr. Esther Zaretsky
- 2. The participative panel on Academic Ethos, Pathos, and Logos generated the following invited articles:
 - *Research Ethos: In the context of Academic Ethos, Pathos, and Logos* by Professors Nagib Callaos and Bekis Sánchez (This article is based on the presentation made by one

of the authors as a panelist, the second author co-identified the meta-ethical ingredient which is missing in some traditional peer reviewing methodologies, and consequently codesigned, implemented and is maintaining and operating the peer reviewing methodology that included the ingredient of Research Meta-Ethics mentioned in the presentation and in the invited article.)

- Improving Interdisciplinary Competences for Effective Communication in Technology Academic Profiles Oriented to Hardware and Software Networking by Professors Carlos M. Moreno and Maribel Alvarez
- When Robots Play Dice: Can Technology Reflect the Ethos, Logos, and Pathos of the Academy? by Dr. Jennifer Seitzer
- Academic Logos to Ethos and Pathos by Dr. Esther Zaretsky

On behalf of the Conference Organizing committee I would like to express our gratefulness to the authors of the above articles for the additional time they provided the Organizing Committee. Their intellectual effort is really appreciated and valued, because it provides more content to the original meaning of proceedings. Much of the information that flowed in this conference and a substantial part of the opinions (doxa), knowledge (episteme), and experience shared here are not represented in the written articles that provided input to the conference and its respective formal presentations.

The following invited articles are meant to help the potential readers of these proceedings with some information related to: 1) *reflections* that were produced as consequence of the conference or that were shared in it, and 2) *opinions and experience-based reflections* that were shared with the conference audience, or were produced as a consequence of it.

We really hope in following conferences we can find more means to represent the information, opinions, reflections, experience and knowledge that were shared in the conference but are not represented by the formal articles that served as input for the formal presentations.

So, let us also hope that this kind of extension we are making to his post-conference proceedings (or transactions) would provide an incremental contribution to the way we interpreted Steve Job's quote (we included at the beginning of this brief introduction to the following invited articles) in the context of the Organizing Committee's purpose and the a main founding objective of the International Institute of Informatics and Systemics (IIIS)

Professor Nagib Callaos, Ph. D. Conference General Chair

Knowledge Integration and Inter-Disciplinary Communication in Action Research

LA-UR-14-26044

Heidi Ann HAHN, Ph. D. Engineering Sciences Directorate, Los Alamos National Laboratory Los Alamos, NM, 87545, USA

ABS TRACT

In a plenary talk at WM SCI 2012 entitled "Planning for Action Research: Looking at Practice through a Different Lens," this author asserted that behavioral science practitioners, often "back into" action research – they start out doing a process improvement or intervention and discover something along the way, i.e., generalizable knowledge, that seems worthwhile to share with their community of practice. It was further asserted that, had the efforts been conceived of as research from the outset, the contributions to the body of knowledge would be more robust and the utility of the projects would improve as well. This paper continues on that theme.

Action research and process improvement methods are briefly described and compared. A comparison of two Los Alamos National Laboratory engineering ethics training projects – one developed using a process improvement framework, the other using an action research framework – is put forth to provide evidence that use of a research "lens" can enhance behavioral science interventions and the knowledge that may result from them. The linkage between the Specifying Learning and Diagnosing stages of the Action Research Cycle provides one mechanism for integrating the knowledge gained into the product or process being studied and should provide a reinforcing loop that leads to continual improvement.

The collaborative relationships among researchers and the individual, group, or organization that is the subject of the improvement opportunity (the "client"), who are likely from very different backgrounds, and the interpretive epistemology that are among the hallmarks of action research also contribute to the quality of the knowledge gained. This paper closes with a discussion of how Inter-Disciplinary Communication is embedded within the action research paradigm and how this likely also enriches the knowledge gained.

Keywords: Action Research, Process Improvement, Case Methods, Engineering Ethics

1. ACTION RESEARCH AND PROCESS IMPROVEMENT METHODS

Action research, as defined by Kock [1], simultaneously improves the subject of study and generates knowledge. The action research paradigm is used in evaluating social science interventions, such as educational initiatives, organizational development efforts, and behavioral health programs, or the effectiveness of changes to systems with humans in the loop, such as human-computer systems or enterprise business systems.

The classic Action Research Cycle put forward by Gerald Susman and Roger Evered in 1978 [2] is shown in Figure 1. It comprises five stages:

- Diagnosing identifying improvement opportunity or a general problem to be solved
- Action Planning considering alternative courses of action to attain the improvement or solve the problem
- Action Taking selecting and implementing a course of action
- Evaluating studying the outcomes of the selected course of action, and
- Specifying Learning reviewing the outcomes of the evaluation stage and building knowledge by describing the situation under study

The output of Specifying Learning may lead to additional iterations of the cycle, serving as input to a new diagnosis.

One typical process or product improvement cycle is the PDCA or Plan-Do-Check-Act cycle that was derived from W. Edwards Deming's work [3] beginning in the early 1950's. As the name implies, the PDCA quality management cycle is a four-step process:

Plan – identify the targeted improvement and the expected output



Figure 1. The Action Research Cycle [2]

- Do implement the change and collect data needed to confirm or refute the satisfaction of the expected output
- Check compare the actual results collected in the Do step to the expected results
- Act analyze the causes of differences between actual and expected results

Corrective actions may be requested, leading to another iteration through the PDCA cycle. Corrective actions most often take the form of additional improvements to the product or process under study, however, it is also possible that the goal state will need to be altered based upon improved information. Figure 2 provides a representation of the PDCA cycle.



Figure 2. The PDCA Cycle¹

2. COMPARISON OF ACTION RESEARCH AND PROCESS IMPROVEMENT METHODS

On the surface, it appears that the primary difference between action research and process improvement is the inclusion in action research of the step "Specifying Learning." And, it is true that the PDCA cycle generally limits knowledge-sharing to the enterprise rather than contributing to the generalizable body of knowledge. However, the differences are actually deeper and more subtle than that.

Although both paradigms sound a lot like the scientific method, they are epistemologically different. The PDCA cycle is built on a positivist epistemology. Positivists generally assume that reality is objectively given and can be described by measurable properties that are independent of the researcher. Positivist research is characterized by formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from a sample to a stated population [4].

In contrast, action research reflects an interpretive epistemology. Interpretivists generally attempt to understand phenomena through the meanings that people assign to them. Interpretive

¹ Attribution for Figure 2: By Karn-b - Karn G. Bulsuk

(http://www.bulsuk.com). Originally published at

research does not predefine dependent and independent variables, but focuses on making sense of emerging situations [5]. Generally, practice- or theory-based questions, rather than formal hypotheses, are used to guide the data collection and analysis.

This difference in perspective influences the types of data collected in the two paradigms. Generally, the data used in PDCA is quantitative and focused on attributes of the process or product. In action research, observation of participants, surveys, and interviews are the most common data collection methods. This is not to say that the methods are strictly limited to either quantitative or qualitative data. In PDCA, for example, qualitative assessments of the subjects' perceptions of the "goodness" of the process or product may also be performed. In action research, quantitative measures, such as throughput of an educational intervention, may supplement more subjective or qualitative data for PDCA and qualitative data for action research.

One final important difference between the two paradigms is with respect to the relationship between the researcher and the subjects of the study. A hallmark of action research is tight collaboration between the researcher and the individual, group, or organization that is the subject of the improvement opportunity (the "client"). This occurs in all steps, with the possible exception of Specifying Learning, which may be the sole responsibility of the researcher. In positivist research like PDCA, the practitioner is more likely a detached spectator, and the client is an object to study [2]; direct interaction with the subjects is usually limited or even non-existent.

3. ENGINEERING ETHICS TRAINING PROJECT OVERVIEW

In 2012, this author presented a paper [6] titled "Adapting the Case Model Approach for Delivery of Engineering Ethics Professional Development Units (PDUs)" describing how engineering ethics case studies were used to meet a need that members of the Los Alamos National Laboratory's (LANL's) workforce had to obtain professional development units for maintaining professional engineering licenses and other professional certifications.

A needs analysis conducted in accordance with the Systematic Approach to Training (SAT) [7] concluded that given the large target population (about 120) who need ethics PDUs on a biennial basis to meet New Mexico (NM) State licensing requirements and cost and logistical constraints related to LANL's remote geographical location, lack of vendor-provided training in the area, and the inability to tailor vendor-provided online training to incorporate LANL-specific requirements, inhouse delivery of engineering-ethics training that could be used to fulfill PDU requirements was the preferred solution. Because of the recurring nature of the requirement and the static nature of the information (i.e., the core principles of engineering ethics are relatively constant), it was determined that workers should be exposed to an initial, in-depth training followed by annually updated refresher training (which is defined as a "short-term course aimed at recall and reinforcement of previously acquired knowledge and skills" [5]).

http://www.bulsuk.com/2009/02/taking-first-step-with-pdca.html (Own work) [CC-BY-SA-3.0 (www.creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Developed in accordance with SAT [7], the initial training covers the elements of the NM *Code of Professional Conduct – Engineering and Surveying* (NMAC); ethical obligations to the engineering profession and other professionals; and various federal legal requirements, most especially export control law, that have the potential to impact the practice of engineering at the Laboratory. It has been delivered both in classroom and online settings. Although the initial training does incorporate some case-based "test your knowledge" exercises, it is primarily a lecture- or presentation-based pedagogical model.

Unlike general ethics courses, which are fairly flexible in the content they present in any given year, the content of the engineering ethics course is relatively static – for instance, the NMAC, which changes only infrequently, must be addressed each time. While the NM state requirements could have been met by having the target audience retake the initial training each year, this would not have been very satisfactory from the learner's point of view. This is especially true in light of the literature from the field of "androgogy," or the art of teaching adults, which suggests that lectures, and especially lectures in which the same information is repeated, may not be the ideal instructional model for adult learners [8]. Therefore, as the engineering ethics refresher training was being designed, other instructional designs were considered.

Case-based instruction was the preferred pedagogical model because it was seen as best meeting the needs of adult learners, as described by Knowles, Holton, and Swanson [8]. Online delivery was preferred to enable the greatest throughput, at the learners' convenience, and with the least cost. Because there was a concern about online delivery of cases not affording the richness of classroom discussion, the online cases were initially designed with branching, which enabled learners providing incorrect responses to explore the case further or to receive feedback as to why their selected response was not the best answer.

Both the initial training and the refresher were developed using a PDCA-like paradigm - the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model from the Systematic Approach to Training [7]. As a result of using a process improvement frame, the success metrics selected were all quantitative and were aimed at answering the questions of whether the intervention had been effective at delivering PDUs to the target audience and whether the training was good at transferring the knowledge. Participants were not surveyed about the efficacy of online delivery of case studies, so it was not possible to answer questions such as whether the trainees found the case method to be pedagogically more appealing than traditional lecture-based methods, as had been theorized, or whether the branching incorporated into the instructional design was an adequate surrogate for the feedback provided via dialogue in traditional face-to-face case methods.

In a keynote address entitled "Planning for Action Research: Looking at Practice through a Different Lens" delivered at WMSCI 2012 [9], this author speculated as to what the engineering ethics training project would have looked like had an action research lens been used instead of the PDCA paradigm, stating:

- The Diagnosis would have been the same there was a need to provide PDUs for the target audience and to refresh trainees' knowledge on engineering ethics principles as a result of their experience with the intervention
- Action Planning and Action Taking would also have been the same – the literature on adult learning and cost and logistical requirements guided the choices
- Evaluation would have been different, as explicit consideration of the pedagogical value of the intervention would have been included
- As a result, Specifying Learning would have had added value in terms of the knowledge gained over and above that obtained when using a process improvement frame of reference

Because the need for delivery of engineering ethics PDUs is ongoing, this project provided a rare opportunity for a do-over. As described in the WMSCI 2014 Proceedings [10], the 2012 version of the engineering ethics case studies was designed incorporating an action research perspective from the outset. Both the intervention itself and the data collection scheme were modified. A moderated discussion board was included as part of the courseware in the hope of augmenting the richness of the case experience beyond what the branching used previously could provide. Data collection included some of the more qualitative measures suggested by the action research paradigm. In addition throughput and correct response rate data, formal participant reaction regarding the effectiveness and utility of the course, the effectiveness of case studies in meeting the needs of adult learners, and the value of the discussion board were also solicited. The survey used (see Figure 3) was a modified version of Thalheimer's learner survey [11]. Unlike many "smile sheets," which ask general questions about the learning experience, this survey format asks learners to respond to specific learning points covered in the learning intervention. The learning objectives for the refresher training were used as the key learning points to survey against.

Capturing data about the *value* of individual key concepts provides more meaningful information about changes that should be made in future learning interventions [11]. In addition to addressing general ratings, the evaluation form also asks two critical questions related to how likely the concepts learned will be utilized on the job and how likely the concepts will be shared with others. This provides information regarding whether the training is likely to have an impact where it was intended.

Modifications to Thalheimer's [11] basic structure included questions related to participant preferences regarding case-based learning as compared to other instructional methods along the andragogical factors suggested by Knowles [12] and questions related to the utilization and value of asynchronous discussion augmentation of the online cases. It was hoped that this would validate the conclusion that a case-based model is the most appropriate method for delivering the educational experience to an adult target population and to gauge the effectiveness of threaded dialogue in improving the richness of the learner's experience and the quality of the feedback provided.

impressions of the Learning Experience for	the Engineering Ethics case study Refresher						
Value of Speci	fic Information						
Learning Concept	Circle ONE Number Below						
Making better decisions when faced with ethics related 1. Most people already know this situations. 2. I already use this concept regularly. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me. 5.							
Being knowledgeable regarding the Rules of Professional 1. Most people already know this Conduct that apply to Professional Engineers licensed in the state of New Mexico. 1. Most people already know this 3. Provided a nice reminder. 3. Provided a nice reminder. 4. Deepened earlier understanding. 5. Concept was new to me.							
Knowing how to identify and resolve business situations requiring ethical judgment.	 Most people already know this I already use this concept regularly. Provided an ice reminder. Deepened earlier understanding. Concept was new to me. 						
Knowing where to go to get help when I am unsure about my best could of action.	 Most people already know this I already use this concept regularly. Provided a nice reminder. Deepened earlier understanding. Concept was new to me. 						
Overall	Ratings						
Rate the overall value of the learning experience. (Circle ONE number to the right. Please don't circle the words.)	VeryLittle Average Very Value Valuabl 1 2 3 4 5						
Rate the likelihood that you will use what you learned within the next two weeks. (Circle ONE percentage to the right.)	0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 1009						
Rate the likelihood that you will share what you learned with a coworker or friend within the next two weeks. (Circle ONE percentage to the right.)	0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100						
Overall C (Provide specific comments on any aspect of	omments the learning experience in the space below.)						

Figure 3. Thalheimer's Basic Learner Survey

4. DIFFERENCES IN KNOWLEDGE GAINED USING A PROCESS IMPROVEMENT FRAME OF REFERENCE VERSUS AN ACTION RESEARCH FRAME

Learnings that would not have been available had a process improvement framework continued to be used were attained in each of the following areas: value of the information imparted, likely impact of the training, the effectiveness of case models in meeting the needs of adult learners, and value of the discussion board. (Results on the quantitative measures of throughput and retention are detailed in the WMSCI 2014 Proceedings paper [10] and will not be repeated here.)

Of the 59 trainees who took the 2012 refresher, 29 completed the survey, for a response rate of 49%. Table 1 shows the results regarding the value of specific information relative to the learning objectives. The most common response across all learning objectives was that the materials "provided a nice reminder." This result is not surprising given that the case studies were intended to refresh knowledge gained through prior training. The results on the questions related to the likely impact of the training were positive – trainees generally reported a high probability that they would use what they learned in their job and that they would share what they had learned with their coworkers.

Learnings about the case method's support of adult learners are shown in Table 2. There were two adult learning principles for which the case method provided better support than presentation-based methods: the tendency toward movement from dependency upon an instructor to greater autonomy and self-directedness and the orientation toward learning as being problem-centered and contextual. The methods were viewed as equally supporting the remainder of Knowles' [12] principles by a plurality, if not a majority, of respondents. In no case was the presentation-based method of instruction viewed as best supporting the andragogical principles by a plurality of respondents. These results were somewhat surprising. It was thought that case methods would be seen as better supporting Knowles' principles related to incorporation of learners' experience bases and incorporation of the various roles that they had played in their professional lives, especially because the cases had been designed to allow the trainees to explore the cases from the point of view of involved workers, managers, and others. Comments on the case method received in response to an positive: open-ended question consistently were

TABLE 1. VALUE OF SPECIFIC INFORMATION

Learning Objective	Rating				
	Most people	I already use	Provided a	Deepened earlier	Concepts
	already knowthis	these concepts	nice reminder	understanding	were new to
		regularly			me
Making better decisions when faced with ethics-related	3.6%	7.1%	57.1%	32.1%	0.0%
situations					
Being knowledgeable regarding the Rules of	3.4%	13.8%	41.4%	41.4%	0.0%
Professional Conduct that apply to Professional					
Engineers licensed in the State of New Mexico					
Knowing how to identify and resolve business situations	3.4%	13.8%	48.3%	31.0%	3.4%
requiring ethical judgment					
Knowing where to go to get help when I am unsure	0.0%	17.2%	41.4%	34.5%	6.9%
about my best course of action					

TABLE 2. RATINGS OF INSTRUCTIONAL DELIVERY METHODS

Adult Learning Instructional Design Principle	Rating		
	Most people already	I already use these	Better supported by presentation-
	knowthis	concepts regularly	based instruction
The need to know not only the subject matter, but also the why, what,	37.9%	44.8%	17.2%
and how underlying it			
The tendency toward movement from dependency upon an instructor	58.6%	37.9%	3.4%
to greater autonomy and self-directedness			
The need to incorporate the learner's experience base as an integral	37.9%	51.7%	10.3%
part of the instruction			
The orientation toward learning as being problem-centered and	55.2%	37.9%	6.9%
contextual			
The need to incorporate the various roles that the learners play/have	41.4%	51.7%	6.9%
played in their professional lives			
The basis of the learner's motivation being in the intrinsic value of the	24.1%	69.0%	6.9%
learning and personal pay-off			

"The case method puts a real world perspective on the lessons and, especially when consequences of failure to behave ethically are demonstrated, it makes the lesson have meaning."

"For this subject matter, case studies seem to be more meaningful."

The only negative comments received had to do with learners being uncomfortable with the lack of a definitively right or wrong answer for many of the scenarios:

> "Ethics can be black/white, but sometimes it is gray (or striped or polka-dotted)... these gray areas are the hardest thing for engineers to come up with the 'right answer."

These were consistent with comments that had been received informally in prior years, including relative to the initial presentation-based training, and served to substantiate a hypothesis that the discomfort was due to the nature of the subject matter rather than an inherent weakness in the case method, as had been postulated by the Food and Agriculture Organization of the United Nations [13].

About 20% of survey respondents reported visiting the discussion board, and 100% of those who did visit rated the experience as being of average or greater value. But, not one of those who reported visiting actually contributed – all of the

comments there were planted by the instructor. Based on the number of hits on the site it is clear that some trainees did visit, but they lurked.

Figure 4 shows that changes resulting from use of the action research frame of reference were more substantive than had been anticipated. Not only did the evaluation change, going even beyond what had been predicted, but diagnosing and action planning and action taking changed as well. And the result was, in fact, that the knowledge gained in specifying learning was far more robust than had been possible previously.

5. INTERDISCIPLINARY COMMUNICATION IN THE ENGINEERING ETHICS PROJECT

One important difference between the process improvement and action research paradigms is with respect to the relationship between the researcher and the subjects of the study, with action research being characterized by tight collaboration between the researcher and the client.

The engineering ethics project affords an opportunity to illustrate the differences in communication and involvement of the subjects in generating knowledge when a process improvement framework was used versus when an action research frame was employed.



Figure 4. Changes to Engineering Ethics Intervention Resulting from Use of an Action Research Frame of Reference



Figure 5. Communication in the Process Improvement Paradigm

As shown in Figure 5, in the process improvement case, the initial problem identification came in the form of queries from the engineers needing PDUs regarding how they could fulfill their continuing education requirements. This problem was turned over to the training specialists, who planned and implemented the initial solution – an online presentation on the NM Professional Code and various professional society and institutional policies related to ethical situations pertinent to the engineering workforce. The only metric applied was the number of people who took the course. There really was no specification of learning – the training team discussed the courseware and throughput among themselves; this led to the additional diagnosis of the need for refresher training.

The cycle was repeated again, still with communication within the training community, but without engaging the trainees. The training specialists included the need for refresher training in the diagnosis; modified the solution to include refresher training using case studies (and action that had been suggested by research into adult learning); and added a metric, correct response rate, intended to assess whether information was being retained.

That mode probably would have continued had not something else happened: The call for papers for WMSCI 2012 prompted a realization that there were learnings from the project that might be of interest to the ethics education community of practice. Engagement with a different community of practice led directly to knowledge generation that would not have happened had the researchers within the single discipline communication "cocoon."

In addition, this author was invited to present a keynote on action research at WMSCI 2012. This caused a change in thinking about the project, from using a process improvement frame to using an action research frame. That, in turn, led to a richer diagnosis as well as much greater engagement with the "subjects" of the research.

While the training specialists still had responsibility for planning and implementing the solution, the action taking phase was designed to afford the opportunity for direct engagement with the learners through a discussion board.

The evaluation phase was the area most affected by adoption of an action research paradigm. Learners were directly involved in evaluating the value and impact of the intervention as well as the degree to which the case method meets the needs of adult learners.

The inclusion of the learners' perspective added to the knowledge generated in a way that had not been possible using the observational methods employed under the process improvement paradigm. The information about the value, impact, and effectiveness of the case models is more robust than throughput and response rate data could provide. In addition, new knowledge was obtained about the efficacy of case models vis a vis other methods in meeting adult learners' needs. This is shown graphically as Figure 6.

As stated previously, there was, however, a void in the knowledge gained when it came to the efficacy of the discussion

at Practice through a Diffe	rent Lens> Dia	ground and	ed to problem statement
Generated more robust information about value, impact, and effectiveness of the intervention	Specifying	Actio	n
Generated new knowledge about the efficacy of case methods	1		Training specializes still had responsibility for planning and implementing solution
	Evaluating	Action Taking	But, the solution included
Laarners direct involved in evo	fy Austion		option for direct engagement with the learners

Figure 6. Communication in an Action Research Frame

board. Recall that there had been a concern from the start of the project that online delivery of the case studies would not provide the richness of experience afforded by the opportunity for dialogue in a classroom setting. The idea of using branching to allow further exploration of the cases was the first solution to this "problem," then an online discussion board to facilitate direct engagement among the community of learners was added. The plan was to evaluate the quantity and quality of posts and to ask learners about the value of the discussion board. When no learner posts materialized, the only evaluation method was learners' perceptions of the value of the discussion board, which gave contradictory results when perception and behavior were compared, as was described previously.

The root of the problem most likely resides in the absence of inter-disciplinary communication regarding this aspect of the "problem." In this case, the training specialists were back to talking among themselves. The question of whether the online delivery of cases suffered from a lack of richness was never formally included in the problem statement, nor was consideration of what effect branching might have had on mitigating the problem if there was one! Feedback from the learners on this topic could have provided invaluable knowledge that might have influenced the trainers' instructional design decisions.

To summarize the communication patterns in the two paradigms, as Figure 7 shows, when all of the communication occurred within the Training Community of Practice, it was possible to solve the problem that had been identified – getting the engineers PDUs and refreshing their learning annually. Research into pedagogical models and assessment of their fit with the characteristics of adult learners generated learnings worthy of contribution to the generalizable body of knowledge.

Interactions with the Action Research Community of Practice led to a whole new approach, influencing the Training Community of Practice, in particular with regard to how the intervention was evaluated. This, in turn, led directly to the trainers' engagement with the Community of Learners, which generated additional knowledge about the suitability of case





methods for meeting the needs of adult learners, and provided feedback to the Training Community regarding the value and impact of the intervention.

5. CONCLUSIONS

In this paper, convincing evidence has been provided indicating that looking through the lens of action research when planning social science interventions or process improvement initiatives can both enhance the effectiveness of the initiative and improve the value of the resulting contributions to the practitioner community's body of knowledge. Greater knowledge is gained through action research than is typically attained using traditional PDCA methods. The knowledge can then be incorporated within the Action Research Cycle to improve the intervention under study.

The interpretivist frame of reference that is characteristic of action research causes inter-disciplinary communication to be embedded into action research projects, by encouraging interaction between the researchers and their subjects as well as between the discipline-specific communities of practice associated with the subject of the intervention and the action research community itself. Inter-disciplinary communication, too, contributes to enriching the knowledge gained.

And so, for the LANL engineering ethics training project, the cycle continues. In the WMSCI 2014 *Proceedings* paper [10], it was noted that consideration was being given to actions to incentivize trainees to contribute to the discussion board – such as offering additional PDUs for substantive participation. As a result of renewed interaction with the Action Research Community of Practice, that idea has been rethought. Instead, the trainers will engage with the learners to understand whether there actually is a problem with the richness of the online case experience; the likely effectiveness of mitigations, including branching and the discussion board, in addressing the problem if it exists; and to understand the dynamic involved in learners placing value on the discussion board but not actively participating in it, before making any additional modifications to the intervention.

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A Discipline-Independent Approach to a Higher Cognitive Pedagogy

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ABSTRACT

We present a content-independent formulation of higher cognitive pedagogy, by identifying higher cognitive pedagogy with executive function which in turn we equate with continual multi-dimensional processing of drivers of outcomes. The key focus in this definition is on *multiple* dimensions. We apply our definition to four diverse disciplines: a) mathematical modeling of verbal problems is presented as an interaction between the dimensions of language and algebra; b) complex mathematical problems are presented as an interaction between multiple subproblems participating in one solution; c) essay writing is presented as an interaction between specific atomic competency skills - creating meaningful sentence pairs - and hierarchical organization into greater wholes such as paragraphs and essays; d) foreign language translation is presented as a dimensional parsing of hypernyms and hyponyms; similarly, literary translation is presented as a dynamic interaction between multiple dimensions of a literary work. We show consistency and correlation between the executive-function pedagogical approach and the Bloom-Anderson approach.

Keywords: cybernetics, executive function, multi-dimensional processing, modeling, complex mathematical problems, organizational writing, Bloom-Anderson, hypernyms, hyponyms

1. OVERVIEW

Many independent sources have called for a reform of modern education with an emphasis on *higher order thinking skills*. Consequently, implementation of reform requires a precise definition of *higher order thinking skills*.

1.1 The Traditional Approach

The traditional approach of defining higher order thinking skills is to present hierarchies of learning attributes. This approach was initiated with the Bloom taxonomy [4]: – *knowledge, comprehension, application, analysis, synthesis and evaluation.* This taxonomy is typically applied as follows: If one is teaching a discipline, one evaluates each module and learning unit by ascertaining if the primary focus is exclusively on knowledge and comprehension versus whether applications of the learning unit are presented which require analysis, synthesis and evaluation on the part of the instructor and student.

Several other pedagogists, for example, Anderson [2], Webb [29-31], Marzano [20], present competing or complementary hierarchies. Some pedagogists – for example, Gagne [10], and Van Hiele [28] – characterize their hierarchies as representing stages of learning.

A recent development in this use of hierarchies is the

demonstration of a correspondence and consistency between superficially different hierarchies. Thus Yazdani [33] showed the approaches of Gagne and Van Hiele equally effective in teaching geometry; Hess [13,14] studied the interaction of Bloom-Anderson and Webb by creating a matrix and classifying several thousand mathematics and English homework assignments in K-12 by their Webb and Bloom levels.

1.2 This Paper's Approach

In Section 2, we approach the problem of defining higher order thinking skills by appealing to brain function. More specifically, we identify higher order thinking skills with activities requiring executive brain function. While executive function itself is an elusive concept, there being several aspects to executive function [22,26], it is generally agreed that executive function is a higher order brain function. Executive function refers to the capacity of the brain to deal with complex tasks. By explicitly relating higher order thinking skills to brain function we take one step towards objectifying and concretizing the definition.

We provide further concretization by identifying commonality in several executive-function performance tests. Several tests of executive function assess continual multi-dimensional processing of environmental information to accurately determine drivers of outcomes. This, the multi-dimensional processing of information to determine drivers, becomes our working definition of higher order thinking skills.

Such an approach is objective, operational and mechanistic. It enables an instructor to instantly evaluate learning material for the presence of higher order thinking skills.

1.3 Atomic Skill Competencies

We have identified higher order thinking skills with multidimensional processing. We further suggest identifying the atomic skill competencies of each educational domain as the multiple dimensions interplaying in determining outcomes. In Section 2.2 we rigorously define atomic skill competency.

1.4 Cybernetic Approach

Throughout our discussion, analysis is exclusively dependent on information flow and independent of content. The analysis of a complex domain in terms of information flow independent of content is the distinguishing attribute of cybernetics [8].

We are particularly indebted to the cybernetician Ashby [9] who focused on eliminating terms such as *higher order* from psychology and replacing them with more mechanistic and operational concepts. In so doing, Ashby was not trying to remove complexity from psychology but on the contrary, trying to preserve it in a more respectable manner.

1.5 Outline

Section 2 presents the definitions of executive function and atomic skill competency. Sections 3-6 apply our definitions to the domains of verbal-problem modeling, English writing, mathematics, literary criticism and foreign language translation. The application of our definition to such diverse disciplines supports the content-independent nature of our approach.

2. EXECUTIVE FUNCTION AND ATOMIC SKILLS

This section reviews executive-function performance tests, clarifies the meaning of multi-dimensional processing, rigorously defines skill competency, and uses these two concepts - skill and multi-dimensional processing - to define our approach to pedagogy which we show consistent with Bloom-Anderson.

2.1 Executive Function Performance Tests

As already indicated in Section 1, executive function refers to multiple brain functions. There are multiple executive function tests the two main categories being performance and rating tests [26]. We examine three well known performance tests.

The Wisconsin Card Sorting Test (WCST) [12]: During the administration of the WCST, the examiner flashes several dozen two-row items such as those found in Figure 1. The examinee is asked to match the card in the bottom row with the appropriate card in the top row. An illustrative example is presented in Figure 1.



Figure 1: A sample item in the WCST. Throughout this section performance tests have been modified, from their standard format, for typographical reasons and reasons of space.

Abstractly, Figure 1 presents three dimensions: a) letter (A,B,C), b) formatting (bold, italic, underline), and c) number (1,2,3). The examinee must determine if the two A's in the bottom row of Figure 1 resemble the A card because of the dimension of letter, resembles the B card because of the dimension of number or resembles the C card because of the dimension of formatting (both are underlined).

Typically, after a few attempts the examinee will discover the correct driver of resemblance. The examinee will then have a streak of correct answers. The examiner may then change the driving dimension. For example, if in the last 10 trials the correct answer was based on a match of number, the examinee may create new trials where the correct match is based on the dimension of letter resemblance.

A wealth of information is gathered during the test. For our purposes, we see that the examinee is being tested on *his/her* capacity to correctly identify the driving dimension from a set of competing multiple dimensions (formatting, number, letter). Furthermore, as time progresses the examinee must continuously reassess the correct driver of correctness. We conclude that the WCST is measuring the capacity of the examinee to *continuously process multiple-dimensional drivers of outcome.* We argue that this is the essence of higher order thinking skills.

The Trailmaking test [6,7,11]: This deceptive but beautiful test has two parts: A and B. In both parts, the examinee is asked to make a trail: In part A, the trail is 1-2-3-..., while in part B, the trail is 1-A-2-B-3-C.... An illustrative example is presented in Figure 2. Although these tasks are easy, remarkably, the part B test always takes longer. The increased length is due to the presence of two dimensions: number and letter. The multi-dimensionality requires executive function and hence the increased time length. Despite the test's simplicity, it is useful in diagnosing brain damage and recovery possibility, for example after a stroke.



Figure 2: A sample Trailmaking test.

The simplicity of this test highlights the importance of our proposed definition that higher order thinking skills equate with multi-dimensional processing. The trailmaking test is making the powerful point that *any* multi-dimensional processing transforms a mundane exercise into executive-function quality. Indeed, just adding the dimensions of letter to the dimension of number in the simple task of making a trail raises the quality of the task to executive-function quality.

The Stroop Interference Test [16, 25]: In this test, the examinee is presented with two lists of words and asked to identify the color of each word in the list. The first list typically has only one dimension, color, and hence can be done quickly. The second list has two dimensions word meaning and letter color. For example the word "red" may be written in blue font, requiring the examinee to process two dimensions, word meaning and color, to arrive at a correct answer. This multi-dimensionality requires executive function and hence the second test typically requires more time (over several dozen trials), something measurable.

Summary: We identify higher order thinking skills with executive function. Executive-function performance tests measure the capacity to continuously process competing multiple dimensions to ascertain driving forces. We conclude that higher order thinking skills should be identified with multi-dimensional processing capability.

2.2 Atomic Skill Competencies

Although the pedagogic literature uses the word *skill*, it is infrequently (if ever) precisely defined. The psychological literature defines a skill as any task that *under repeated performance a*) *increases in speed and b*) *decreases in error rate* [19] For example, reciting the alphabet, plugging into a mathematical formula, developing a topic sentence by giving examples or consequences, are all examples of skills.

Contrastively, writing an essay, doing a complex math problem, writing a complete computer program are all non-skill acts. For example, you cannot speak about the error rate in writing an essay since essays are not right or wrong. Similarly, increased practice does not increase essay writing speed. It is not a skill. We now explain the word *atomic*. An atomic skill competency is a skill that cannot be decomposed further. For example, writing a paragraph basically consists of applying multiple skills, that is, multiple methods of developing topic sentences. A topic sentence may be developed by *cause, consequence, example, analogy, contrast* etc. *Each* particular method of development is an atomic skill competency: You can practice say developing a topic sentence by *consequence* until you can do so quickly and without error. Contrastively, the *entire* paragraph writing, the development of the topic sentence, is a skill composed of multiple atomic skills. Writing a paragraph is a skill competency but not an *atomic* skill competency.

Of utmost importance is that atomic skill competencies need not be classified exclusively as memorization and performance, lower order skills. To fully understand this recall that our definition of higher order thinking skills exclusively requires the presence of executive function. A recent study [15] shows that memorization and performance when combined with executive function is higher order; in fact, multi-dimensional performance surprisingly improves intelligence.

In this study, number-letter pairs were flashed at three second intervals to an examinee who had to identify resemblances to pairs two trials earlier. For example, in the sequence #1) 2A, #2) 3B, #3) 4A, #4) 3A, #5) 4A, the examinee has to recall that trial #3 resembles trial #1 in the dimension of letter, trial #4) resembles trial #2 in the dimension of number, and trial #5 resembles trial #3 in the dimensions of number and letter. The examinees practiced these recalls, 20 trials at a time, each trial exposure being three seconds. Over a period of several sessions, performance increased and error rate decreased, the criteria for atomic skill competency. The surprising result was that the practice also increased general fluid intelligence. We attribute this to the multi-dimensionality of the recall, which required that two dimensions, number and letter be recalled. Such multidimensionality requires executive function and it is not surprising that executive function increases intelligence.

2.3 The Executive-Function Approach to Pedagogy

We are now in a position to give a full statement of our approach to pedagogy.

The role of the instructor, or alternatively, the goal of instruction, is

- a) To identify the atomic skill competencies of a domain of knowledge,
- b) To provide exercises and other resources to enable mastery of these atomic skill competencies,
- c) To present higher cognitive problems requiring choosing between, and combining of, multiple dimensions - each dimension consisting of a single atomic skill competency – to achieve desired solution outcomes.

Examples will be presented in the remaining sections of the paper. For the moment we note consistency and correlation of the executive-function approach with the Bloom-Anderson approach since performance of atomic skill competencies corresponds to the lower order Bloom-Anderson levels of knowledge and comprehension while the analysis of multidimensional problems corresponds to the higher order Bloom-Anderson levels of analysis (into component dimensions), synthesis and evaluation (determining which competing dimensions drive outcomes). We have deepened the understanding of Bloom-Anderson by adding specificity, mechanistically identifying the terms *synthesis, analysis* and *evaluation* with multi-dimensional processing and by further identifying *knowledge* and *comprehension* with atomic skill competency.

3 EXAMPLES: MODELING

In the next four sections we illustrate application of the executive function approach of pedagogy to several disciplines. In this section, we apply the executive-function approach to modeling of verbal problems. Modeling is a key example of higher order thinking skills and is frequently mentioned in discussions of educational reform [24].

The key point to emphasize about modeling is that it requires a continual multi-dimensional processing of the two dimensions of algebra and language. This is illustrated in Figure 3.

English	Math
Amy purchases	
4 Peanut bags	4P
And	+
1 orange juice quart	10
For a total of	=
6 dollars	6
Bonnie purchases	
1 peanut bag	1P
And	+
4 orange juice quarts	40
For a total of	=
9 dollars	9
How much does	Solve for
1 peanut bag	Р
And 1 orange juice quart	Q
Cost?	

Figure 3: Verbal modeling of a purchase problem with the two equations 4P+1Q=6, 1P+4Q=9. The table should be read both vertically (English, Math) and horizontally (English-Math correspondence)

English Phrase	Mathematical Correspondent			
And	+			
For a total of	=			
Number followed by noun	Number x Noun symbol			
E ! 4 G 111 ¹¹ · · G 1	1 1 1 1 1 1 1			

Figure 4: Small list of verbal-algebraic skill competencies.

Figure 4 illustrates a small list of atomic skill competencies. I have found this approach – creating verbal-algebraic tables – extremely useful when teaching modeling to remedial students. Some would argue that I am replacing thinking with memorization of lists. But a deeper analysis shows this untrue. We have already cited results [15] that memorization can increase intelligence provided executive function is involved. Figure 4 illustrates such a memorization since it requires the two dimensions of language and mathematics. Figure 4 should be perceived as an *exercise* of executive function. I have seen, that after students successfully memorize Figure 4, they are more adept at new English-Math translation situations.

4 EXAMPLES: COLLEGE WRITING

There are a variety of approaches to textbooks on collegewriting. The Jones-Faulkner [17] textbook uses executivefunction pedagogy. The book leaves grammar to an appendix! The body of the book is organized into 3 major parts: sentences, paragraphs and essays. Each part is highly skill driven.

For example, there are 4 categories of sentence-pair types, each category having several subtypes. Typical examples of sentence-pair types are sentences connected by *cause*, *consequence*, *contrast*, *analogy*, *illustrative lists*, *supporting data*, *etc*. Consequently, the first part of the book is devoted to developing skill competencies on sentence pairs. A typical exercise might present several sentences and request creating a second sentence that is a consequence of it. The second part of the book develops skills in the five types of paragraphs. After mastering these skill competencies students are adequately prepared to write complex essays.

Figure 5 illustrates the approach of the book. It presents a paragraph and analyzes the sentence-pair relationships.

Paragraph	Sentence Pair Relationships				
(1) Jim passed several	#1 – Topic sentence.				
actuarial exams. (2) He was	#1,#2 – Consequence				
immediately hired. (3) (3a)	#3,#1 – Cause				
His success was due to (3a)	#4,#3 – Supporting data				
taking good prep courses and	#3a,3b – Parallel sentences				
(3b) spending a lot of time	#3b – List of items/examples				
studying and practicing. (4)					
Indeed, during his period of					
study he did not go to any					
parties.					

Figure 5: Illustrative paragraph and corresponding atomic skill competencies. For example, sentence #2, *Jim being hired*, is the <u>consequence</u> of sentence #1, *his passing actuarial exams*. Similarly, sentence #3- *his taking good prep courses* – is the <u>cause</u> of sentence #1 – *his passing actuarial exams*.

5 EXAMPLE: ACTUARIAL MATHEMATICS

To illustrate the issues in teaching actuarial mathematics, consider the following problem:

5.1 An Illustrative Example

Price, (that is ascertain how much money is needed in the bank) an annuity that pays \$5,000 at the end of year 1, \$5,000 at the end of year 2, \$5,000 at the end of year 3, \$6,000 at the end of year 4, \$7,000 at the end of year 6 and \$8,000 for year 7.

Executive-function pedagogy requires identification of the atomic skill competencies. There are 3 basic annuities which a student must learn to price: *level, increasing, decreasing.*

- <u>Level</u>: A level annuity makes a level payment of \$*x* at the end of every year for *n* consecutive years.
- <u>Increasing</u>: An annuity which pays \$*x* in the first year, \$2*x* in the second year, \$3*x* in the third year etc.
- <u>Decreasing</u>: An annuity which pays nx in the first year, (n-1)x in the 2nd year, etc. until paying x in the *n*-th year.

Students are taught to recognize these basic three annuities, to calculate their purchase price, as well as the symbols and formula associated with them. These are atomic skill competencies since with sufficient practice students can do any of the three basic annuities i) quickly and ii) without error.

The major part of my teaching is devoted to multi-dimensional

analysis of verbal problems, such as the problem introduced at the beginning of this section. One possible multi-dimensional analysis of the problem at the beginning of this section is presented in Figure 6. As can be seen, the sum of two of the three basic annuities – level and increasing – results in the desired payment.

Time	0	1	2	3	4	5	6
Desired		5000	5000	5000	6000	7000	8000
payment							
Level		5000	5000	5000	5000	5000	5000
annuity							
Increasing		0	0	0	1000	2000	3000
annuity							
Sum of		5000	5000	5000	6000	7000	8000
level and							
increasing							
annuity							

Figure 6: Analysis of the desired payments (row (2)) into 2 basic components, a level annuity(row(3) and an increasing annuity (row(4)), whose sum (row(5)) is the desired payment.

In a certain sense, my classroom is flipped: I don't spend time on formulae but rather spend time doing analysis and ask the students, after a brief introduction, to learn and practice formulae on their own.

5.2 Comparisons with other textbooks

Kellison edition 2 [18]: a highly respected book that had no competitors for over 10 years, teaches the three basic annuities in the body of the text but only presents multi-dimensional problems such as the example presented in section 5.1, in the exercise section. This approach is used by many textbooks: minimal skills are presented in the text body but analysis and synthesis in the exercises. We advocate the reverse: the majority of textbook and class time should be spent on analysis.

Daniel-Valeer [27]: This textbook presents in the text body both multi-dimensional and atomic skill examples. However, this textbook ingeniously creates a new formula – a new atomic skill competency – that can "solve" two-dimensional problems. Thus the multi-dimensional problems are solved with a *formula* and hence they lose their multi-dimensional challenge.

In summary, it is possible to base an actuarial course on executive function. However, many textbooks prefer to opt the easy way out by leaving students to think on their own or by substituting formulae for thinking.

6 LITERARY CRITICISM AND FOREIGN LANGUAGE 6.1 Overview on Rashi

The material in this section is based on the biblical commentary of Rashi. Rashi is an acronym for Rabbi Isaac Solomon. Although many scholars in several civilizations had commented on the Bible [3], Rashi, a French medieval commentator of the 11th century, was the first commentator to comment both on general literary issues as well as individual words and phrases [5,21].

The derivation of each Rashi comment from the Biblical text has been the subject of much research by many people over several centuries. In this paper, we focus on the fact that rules governing Rashi derivations can be organized into ten categories each of which is composed of atomic skill competencies involving executive function [23].

6.2 Rashi and Executive Function

We have already identified executive function with multidimensionality. We can organize the Rashi rules according to their multi-dimensionality as presented in Figure 7.

- Two Dimensionality in
 - Words *meaning*, grammar
 - Phrases reference, parallelism, contradiction
 - Sentences (Broad/literal interpretation)
 - Paragraph structure (e.g. climax)
 - Languages
 - Multi (more than 2)-Dimensionality
 - Database methods
 - 0 Symbolism

Figure 7:The 10 categories of Rashi rules (italicized) organized by dimensionality and essay units (words, phrases, sentences).

6.3 Examples

Hyponymy [32]: Translation is typically thought of as a non-executive function activity. But in Section 2.1 we showed that even a mundane exercise like alphabet recitation can be transformed into executive function quality if it becomes multidimensional. And indeed, Rashi typically comments on word-pairs involving several dimensions.

Rashi, in his commentary on the grain offerings described in Leviticus 2, explains two Hebrew words describing the cooking utensils, *pot* and *frying pan: "A frying pan is flattened while a pot has height.*" Frying pans and pots are hyponyms of the hypernym cooking utensil. By translating hyponym pairs, Rashi introduces multi-dimensionality since meaning is based on the two dimensions of *function* (cooking) and *form* (height).

Hononymity: On the verse (Gen. 42:23), *They were* unaware that Joseph <u>heard</u> since he had used a translator, Rashi states that "In this sentence, <u>heard</u> means understand. In other words hear **hononymically** can refer to listening or understanding. Here again Rashi introduces multidimensionality since meaning is based on the two dimensions of function (understanding) and form (listening).

Grammar: Rashi also used word pairs to illustrate grammar. On the verse (Ex. 19:18) *And mount Sinai was fully smoked* Rashi comments <u>Smoke</u> is a noun and verb while <u>smoked</u> is an adjective. Here, Rashi introduces multidimensionality since meaning is based on the two dimensions of grammatical function (noun-verb) and spelling (smoke vs. smoked).

Grammar: The text of Num. 12:1 when translated properly reads, *Miryam and Aaron speaks against Moses*. Note the grammatical anomaly indicated by the underlined *s*; proper English is either *Miryam speaks* or *Miryam and Aaron speak* but not *Miryam and Aaron speaks*.

Rashi resolves this contradiction, between a plural subject and singular predicate, by stating *Miryam initiated the conversation while Aaron only echoed and participated Miryam's requests.* Here Rashi introduces multi-dimensionality by modifying the dimension of plural dialogue with a dimension of intensity of plurality (mutual dialogue, or initiated-echo dialogue).

Reference: On the innocuous looking verse (Deut. 26:5) Jacob went down to Egypt with a <u>few</u> people Rashi

references Gen. 46 which lists the 70 people that went down to Egypt. Hence, the terse but executive-function comment: *Few means* 70. Here, Rashi introduces multi-dimensionality by merging the implications of *two* separate texts.

Parallelism: Unlike the *reference* method where the two texts have few words in common (the reference is based on meaning), in the *parallelism* method the two texts are almost identical; minor differences between the two texts illuminates meaning. Here multi-dimensionality is achieved through simultaneous awareness of two phrases. Figure 8 is illustrative.

[In the Messianic era] One washes clothing in wine and Suth in blood of grapes.

Figure 8: Parallel structure of Gen. 49:11.

The parallelism shows *wine* parallel with *blood of grapes* and *clothing* with *suth*. Hence the terse Rashi comment: *Suth refers to a type of clothing*.

Contradiction: Num..8:24 and Num. 4:2 discuss the age when Levites start working in the Temple: One verse says they start at age 25, while the other states they start at 30. Rashi resolves the contradiction: *They start a 5 year training program at 25 and upon completion at 30, start actual Temple service.* Again, Rashi introduces multi-dimensionality by focusing on multiple texts and multiple dimensions of Temple service.

Two languages: Rashi explains the peculiar biblical word *totafoth: It means 4 since <u>path</u> in African means 2 and <u>Tot</u> in Caspian means 2. [The word <i>totafoth* refers to the 4-chambered Tefillin ornament worn by religious people]. Here Rashi introduces multi-dimensionality since multiple languages are being used to explain meaning.

Database: Databases definitionally study relations across multiple dimensions. A rather beautiful example is found in the Rashi commentary on the multi-colored Leviticus 10, a biblical chapter describing i) the death (by God) of Aaron's two sons who impetuously offered an improper sacrifice, ii) Aaron, the High Priest's silence and acceptance of his sons' death, and iii) the Divine command to Aaron prohibiting drunk priests serving.

Rashi performs a simple database inquiry: how are biblical paragraphs introduced: Several dozen biblical paragraphs of God's laws begin with the introductory sentence "God spoke to Moses to say over", while only two paragraphs begin with the introductory sentence "God spoke to Aaron, to say over." This anomaly suggests the following reasonable sequence of events: Aaron's two sons were drunk; they therefore thought they were as good as their father and could offer anything he could offer. When they did so, they died at the hand of God. As a reward for Aaron's acceptance of God's will, evidenced by his silence, he was rewarded with teaching the commandment that priests should not serve drunk.

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Anticipating Serendipity Preparing for the Unexpected

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ABSTRACT

Serendipity—using "fortunate accidents" for learning or discovery—is a valued if too infrequent route to progress. Although serendipity cannot be scheduled or relied upon, one can develop skills, flexibility and habits of mind that make the recognition and incorporation of serendipitous discoveries more likely. This paper overviews at a high level a program of activities and concepts aimed at preparing modern professionals and communities to leverage the fortunate occurrences they encounter.

Keywords: serendipity, discovery, community, collaboration, improvisation,

1. INTRODUCTION

Serendipity, felicitous acquisition or discovery by a combination of fortune and sagacity, derives from Horace Walpole's correspondence commenting on the fable, The Three Princes of Serendip [33, 36], dating in English from the 18th century. As Walpole states, the three princes were "always making discoveries, by accidents and sagacity, of things which they were not in quest of".

Thus serendipity cannot be a direct goal of a program of discovery, since of course it is impossible to schedule luck, but it is possible to inculcate sagacity, by developing flexibility and an adaptable knowledge base, and fostering openness, wisdom, and judgment.

In the rest of this paper, we look at forms and aspects of serendipity, and suggest an approach for a framework to facilitate it. In particular, we look at the connection of serendipity with improvisation, intuition and analogy.

We then look briefly at a broad variety of applications, and at tools that have been developed for its support. Finally, we provide conclusions and recommendations.

2. FORMS AND ASPECTS

It is possible to recognize three forms (or levels) of serendipity: First, recognition of an unexpected situation or result, as in Goodyear's discovery of vulcanized rubber [10], Fleming's penicillin [37], or Plunkett's Teflon [7]. Second, connections via analogy or linkages, as in Kekulé's (possibly apocryphal) realization of the structure of benzene when he dreamed of a self-devouring snake (the Worm Ouroboros) [35]. And third, the integration of multiple perspectives or disciplines through the formation of groups and communities, where one party's knowledge or approach supplies a missing key to a problem faced by another.

The second, intuitive form, is closely related to the idea of the thought experiment. An interesting example of this form, making totally unexpected connections, occurred in the work of the author. After struggling for months to find an algorithm and complexity analysis for a problem in real-time multi-media scheduling [21], it turned out that the problem was essentially analogous to the line-segment intersection problem [32], which the author had encountered only by taking a course in combinatorial geometry because he found the instructor's approach to teaching appealing.

Dealing with the unexpected is the key to the first two forms. As Isaac Asimov once wrote, "The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny'" [4]. But to properly deal with the unexpected, one must admit the possibility, and have sufficient mental flexibility, sensory awareness, and "thinking in the background" beyond the immediate task at hand to be able to cope with fortunate surprises.

One must then be able to recognize that something unexpected has occurred, to assess whether the event has the potential to be interesting, and to modify and adapt plans and projects to explore and possibly incorporate the discovery and/or its consequences, and perhaps even changing processes and approaches.

Finally, one must be able to evaluate the result to see if that incorporation was in fact productive, and as necessary to modify and evolve the result, even if it means reverting to the earlier plan or product.

3. THE COLLABORATIVE AND INTERDISCIPLINARY MODE

Collaboration, interdisciplinary ventures, and the community mode in general call not only for such abilities, but also for more group-oriented and communication intensive skills [27]. (Note that "interdisciplinarity" here means more than teams from different disciplines

investigating related problems, or even looking at different facets of a single problem. An interdisciplinary team collaborates as a unit to bring different disciplines to the definition and solution of a problem, development of a product or formation of a community [28]. Such teams can then work with other teams beyond their immediate circle in the pursuit of problem definition and solution.)

First, recognizing opportunities or occurrences requires additional skills: realizing and then fostering a group's potential for positive and creative interaction; picking up on chance but relevant conversations and observations; or making unexpected connections based on conferences, workshops or (formal or informal) publications. An important point, especially for projects complicated by factors such as interdisciplinarity, longevity, complexity or risk, is appreciating unexpected viewpoints and stakeholder perspectives—or sometimes just expected views stated in unexpected ways—which through use of analogy and transformation can produce not only opportunities for integration, but unexpected insights on one's own perspective.

As these connections are made, one finds oneself in a network of overlapping and interacting communities, where "community" can include not only social and governmental units, or enterprises, professional societies or multiorganizational project teams, but also less formal communities of learning, knowledge or practice, as well as "communities of communities", raising the bar from collaborating individuals to collaborating institutions or groups, with a need for both standards and constraints [15].

Preparing to encounter and leverage fortunate occurrences in this mode relies primarily on two factors. After identifying the prospective community or community of communities, the first is creation and maintenance of an environment of communication and trust, which in turn relies on understanding differences in social, institutional, domain/discipline and work cultures [26, 29].

The second is awareness of and openness to the content of communication. Sometimes the most interesting results arise from fortunate misunderstandings, or from attempts by novices (students, interns, participants from outside the discipline) to formulate the principles and issues in a given problem or situation. Once more, the process of analogy, linking disciplines, and pattern matching is important in different ways both for the novice and for the more experienced listener.

In some well-known cases (for example, [3]), the misunderstanding is on the other side, with the novice solving an "impossible" problem by taking a new tack, because he/she did not realize how hard it was or what the traditional approaches had been.

4. A FRAMEWORK

As a structure for organizing the process of being open to serendipity, we propose a framework of six facets: contextual, conceptual, perceptual, effectual, consensual, and eventual. All are valuable, perhaps necessary, for "fortunate discovery", although the perceptual is more valuable in the individual modes, and the consensual in the collaborative modes.

The first three provide core background. The contextual facet is concerned with the acquisition and organization of knowledge [15] — explicit, undocumented implicit knowledge, and tacit, "hand" or "social" knowledge— together with problem analysis (cost-benefit, requirements and risk [23]) and initial problem evaluation—does a prospective approach seem interesting, useful or sufficiently offbeat as to be intriguing?

The conceptual facet entails problem solving and thinking skills: critical thinking, openness and flexibility together with an understanding of agile approaches and processes [2]. In addition, it stresses the understanding and use of analogy [12, 13, 14] and development and use of intuition [8].

While sensory awareness is important to the perceptual facet, the development of a sense of fun with ideas, relationships and communication, and an awareness of physical and social relationships are also important. Improvisation and role-playing [20] are important tools here, especially when the approach emphasizes initial planning and subsequent revision, together with experimentation and exploration of the senses, ideas and relationships. This facet also leads to better communication skills—also valuable in organizing one's own thoughts—listening, organizing information and persuasion, plus a sense of voice, posture and physical presence.

Figure 1. The Serendipity Framework



Surrounding these three foundational facets are two facets corresponding to growing ideas. The first is the effectual
facet, concerned with acquiring and integrating information from multiple sources, disciplines, individuals or groups [15, 22, 18], reaching beyond the familiar, and via multiple modes of perception and communication, which provide grist for the processes of abstraction, specialization and generalization, and analogy.

The second is the consensual facet, involved in working with groups, or within communities of knowledge or practice. The seeds of community development and interdisciplinary discoveries lie in recognizing and fostering prospective communities, inculcating communication and trust, and placing a value on benefits to and healthy growth of the community. The consensual facet also presents opportunities to flesh out ideas, using the community as a forum or sounding board, yet at the same time realizing that there are times when it's appropriate to disregard the opinion or preferences of the community and to go one's own way [1]. Preparing for collaboration also calls for revisiting knowledge management, to incorporate knowledge resulting from integrating partner knowledge, or resulting from a collaboratively developed and operated product [9, 22].

Finally, judgment, revision and evolution comprise the eventual facet, where these should be applied not only to problem solutions, but to the modeling of problems, and to our solution processes themselves, and reflection on one's own thought processes. The eventual facet echoes and reinforces the deepest tasks in the others: contextual problem analysis, the conceptual facet's flexibility and agility, the planning and revision of the perceptual facet, the effectual facet's abstraction, analogy and integration, and both the conditional acceptance and justified rejection of community opinion and approach from the consensual facet. For this reason, success in developing the eventual facet is a good measure of success in anticipating serendipity.

5. APPLICATIONS

Serendipity is an obvious important partner to improvisation in the creative arts—theater, dance, music, and the visual arts—as well as fine and decorative artisanship, including pottery, woodworking, glassblowing and metalwork; the preparation for these domains will be in the same spirit but differ in the details from that described above.

As importantly, and more closely in line with the above, improvisation and readiness to use fortunate occurrences are of immense value across the spectrum of teaching and training [1, 9, 11, 19]. They also are of immense use in software development and development of other knowledgebased products [17], as well as in management, especially of knowledge workers—where knowledge can be understood to include tacit, "hand" knowledge. In each case, the ability to read the "class" and to elicit new information, sometimes not yet articulated by its members, is often beneficial.

Science, engineering and technology workers will also gain from both improvisational skills and preparation for

serendipity, as indicated by the examples above, and even more so if in collaborative environments, or those in which a complex problem must be defined by multiple stakeholders.

As a final example, this preparation should be recommended for those interested in community planning and development or effective provision of social services, or in collection and curation of oral and artifactual history [18, 30].

6. TOOLS AND SUPPORT

Data mining and visualization are useful discovery tools, although typically limited to information already encoded in the given context. As such, they can be adjuncts, revealing existing patterns and suggesting hypotheses, or suggesting new ones as information is added or modified, but don't themselves add to the context. To promote serendipity, these need to be complemented by tools that make contacts and connections, or that suggest analogies.

Automatic or semi-automatic connection of people with common acquaintances or perceived common background or interests is now common on social media such as FacebookTM, LinkedInTM and others. However, it is both more interesting and more useful (from a research perspective) when those connections are made on the basis of shared knowledge or concerns, or when one appears to have knowledge that will be useful to the other (and hopefully vice-versa), and the results are integrated with enterprise knowledge management.

A number of tools [5, 6, 31] have been developed to support development of a knowledge base with such crossconnections, and the making of connections between people and groups, or between people/groups and topics, using shared technical contacts, publications, projects, and declared interests and memberships to do so. The more sophisticated tools will examine publications and projects to attempt to discover shared techniques, algorithms, concepts, or concerns. Others focus more explicitly on creating a semantic net of concepts labelled with references or artifacts, and notifying interested parties of new connections [34].

An integrated tool for support of collaboration and innovation is presented in [18, 25]. This tool includes both the knowledge and connection base described above, but tools for sharing views of a project across organizations, and robust communication tools. (See also [16, 24], describing a system for software development that integrates project artifacts with collaborator and external information.)

Analogy generating tools are less common, mostly exist in the world of artificial intelligence [13], and are limited both by incomplete context and by a necessarily incomplete analogy-forming rule-base [14]. The author is unaware of any current tool that combines AI-based analogy generation with the sort of connection former described above.

7. CONCLUSIONS

Although one cannot schedule or rely on serendipity, one can develop the flexibility, mental attitudes and skills to improve the likelihood that one will recognize and benefit from fortunate accidents when they occur.

The program of development should include traditional exercises to develop critical thinking and problem solving, together with requirements and risk elicitation and evaluation. These can be specialized to the domain(s) of the participants, with the goal of forming a deeper and more conceptual understanding of its structures. To these can be added study of (general or domain-specific) patterns, the abstraction-generalization-specialization approach, and the use of analogy, and other activities designed to foster intuition, as well possibly as more general surveys of semiotics or visualization.

But these should be supplemented with approaches aimed at fostering communication and creativity, such as improvisation, and with community and group development workshops, and each of these aspects should deal with trust building and differences in cultures, in the broadest sense of that term. Finally, these need to be supplemented with activities that strengthen the analytical facility of the participants as applied to assessing the initial and eventual values of problem, process, and patterns of thought.

The facet structure proposed above will be useful in a broad evaluation of such a program of activities, and may assist in staging, sequencing and refining its activities.

Naturally, large knowledge enterprises and teams involved in multiple complex and interdisciplinary projects will also want a tool suite to facilitate organizing knowledge, making unanticipated connections of both people and information, and evaluating and testing proposed designs or solutions. The combination of preparation, continuing interaction and tool support will facilitate the entire (possibly collaborative) enterprise, and recognition and leveraging of serendipitous occurrences.

Acknowledgments: The author wishes to acknowledge the contributions of Dr. Vassilka Kirova of Alcatel-Lucent and Dr. Susu Nousala of Aalto University.

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The Smarter Planet: Built on Informatics and Cybernetics

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ABSTRACT

IBM's Smarter Planet initiative is a multi-disciplined approach that integrates the key tenets of the IMSCI 2014 (The 8th International Multi-Conference on Society, Cybernetics, and Informatics) conference [1]. Industry has seen a tremendous explosion of data growth. Organizations that dealt with Terabytes (TB) and Petabytes (PB) just a couple of years ago are now faced with the challenge of dealing with Exabytes (EB) of data. An Exabyte is 10^{18} Bytes – a million times a billion bytes! The amount of information available today is truly remarkable; so much that it is considered by many in industry as a new "natural resource." Computing has similarly grown and made major advances. Today's fastest supercomputer is a 33.8 PFLOPS machine (33.8×10^{15}) floating point operations per second) and applies analytics to predict weather to a degree that was unimaginable ten years ago. The Smarter Planet approach goes beyond the traditional data sources to include a plethora of sensor data (e.g., utility readings, concrete pressure sensors on a bridge, etc.) and applies analytics to provide new Informatics, which in turn can be used to advance new Cybernetics (e.g., Smarter Buildings, Smarter Cities) to address Societal needs in new, innovative ways. [2]

Keywords: Smarter Planet, Informatics, Cybernetics, Advanced Analytics, Big Data, Knowledge Management

1.0 INTRODUCTION

The focus of this paper is on the role of Informatics and Cybernetics [1] in the evolution of IBM's Smarter Planet initiative, and a brief description of the underlying computer (data processing) technology advances Smarter Planet is built on. Whereas a traditional Knowledge Management (KM) system [3] [4] automates the Cybernetics and Informatics that an organization utilizes to run various aspects of its business, one can envision the world as the composition of numerous organizations (governments, industries, academic institutions, and even individuals) working together towards common or inter-related goals and objectives. Advanced Analytics can be applied to increase the effectiveness and efficiency of traditional KM systems. [5]

In a seminal speech to the Council of Foreign Relations, IBM Chairman and CEO Sam Palmisano first noted some grand challenges observed world-wide, as a result of several Global Innovation Outlook (GIO) Summit meetings IBM sponsored with leaders and technologists around the world:

"How much energy we waste: According to published reports, the losses of electrical energy because grid systems are not "smart" range as high as 40 to 70 percent around the world.

How gridlocked our cities are: Congested roadways in the U.S. cost \$78 billion annually, in the form of 4.2 billion lost hours and 2.9 billion gallons of wasted gas—and that's not even counting the impact on our air quality. How inefficient our supply chains are: Consumer product and retail industries lose about \$40 billion annually, or 3.5 percent of their sales, due to supply chain inefficiencies.

How antiquated our healthcare system is: In truth, it isn't a "system" at all. It doesn't link from diagnosis, to drug discovery, to healthcare deliverers, to insurers, to employers. Meanwhile, personal expenditures on health now push more than 100 million people worldwide below the poverty line each year.

How our planet's water supply is drying up: Global water usage has increased six-fold since the 1900s, twice the rate of human population growth. According to the Asian Development Bank, one in five people living today lacks access to safe drinking water, and half the world's population does not have adequate sanitation.

And, of course, the crisis in our financial markets: This will be analyzed for decades, but one thing is already clear. Financial institutions spread risk but weren't able to track risk—and that uncertainty, that lack of knowing with precision, undermined confidence." [2]

Recognizing IBM's unique opportunity to provide new leadership and leverage the corporation's 100 years of technical innovation, inventions, and awards [6], Mr Palmisano described IBM's commitment to "building a smarter planet" and the key tenets of the Smarter Planet initiative:

"First, our world is becoming instrumented: The transistor, invented 60 years ago, is the basic building block of the digital age. Now, consider a world in which there are a billion transistors per human, each one costing one ten-millionth of a cent. We'll have that by 2010. There will likely be 4 billion mobile phone subscribers by the end of this year... and 30 billion Radio Frequency Identification tags produced globally within two years. Sensors are being embedded across entire ecosystems—supply-chains, healthcare networks, cities...even natural systems like rivers.

Second, our world is becoming interconnected: Very soon there will be 2 billion people on the Internet. But in an instrumented world, systems and objects can now "speak" to one another, too. Think about the prospect of a trillion connected and intelligent things—cars, appliances, cameras, roadways, pipelines... even pharmaceuticals and livestock. The amount of information produced by the interaction of all those things will be unprecedented.

Third, all things are becoming intelligent: New computing models can handle the proliferation of end-user devices, sensors and actuators and connect them with back-end systems. Combined with advanced analytics, those supercomputers can turn mountains of data into intelligence that can be translated into action, making our systems, processes and infrastructures more efficient, more productive and responsive—in a word, smarter." [2]

This paper describes the dimes at the information and technologies benind the *Systemics Cybernetics and Informatics* (WMSCI 2014) at the information Smarter Planet imitative, which represents a state of the art application of Informatics and Cybernetics fundamentals.

2.0 AUTONOMIC COMPUTING

Enterprise Systems Management (ESM) has evolved over the last forty years, as the size and complexity of systems within organizations have grown. The administration and support of the many system elements (e.g., servers, storage and networks) becomes increasingly challenging as an organization transitions to managing heterogeneous systems across their enterprise. Even today, the majority of our industry struggles to manage system outages, configuration changes, performance tuning, and many other ESM challenges. The Autonomic Computing vision emerged from decades of research and development focused on increasing ESM automation and decreasing the need for human intervention. The term "autonomic" is used to connote the unprecedented level of automation the human body has - i.e., our autonomic nervous systems, which subconsciously governs numerous, complex body functions. For example, our body autonomously measures oxygen levels, body temperature, blood sugar levels, etc. - and then automatically changes respiration, circulation and digestion to dynamically address issues. One doesn't think about increasing one's breathing and circulation when climbing stairs; that's done autonomously by the body in order to control the anomalous exertion being forced on the body.

2.1 TENETS OF AUTONOMIC COMPUTING

Autonomic Computing (AC) has four tenets: Self Configuring. Self Healing, Self Optimizing, and Self Protecting. [7]



Figure 1: Autonomic Computing Tenets

These tenets, illustrated in the figure above, include the following capabilities:

Self Configuring – Many of today's corporate data centers have a variety of components from a variety of vendors. Installing, configuring, and integrating components is time consuming and error-prone. The AC vision is to automate the configuration of components and systems according to highlevel policies; and the rest of the system adjusts automatically.

Self Healing- Determining problems in large, complex systems today can take a team of programmers and system administrators multiple weeks. The AC provides automated detection, diagnosis and resolution to localized software and hardware problems.

Self Optimizing - Today's hardware and software contain hundreds of measurements, diagnostics, alarms, and many more tuning options and parameters. The AC strategy is to continuously seek opportunities to improve performance and efficiency.

Self Protecting – The majority of today's mechanisms for protecting and detecting system attacks and failures are silo'ed and are slowly beginning to use standard security naming

from many disparate protection and detection system elements, to automatically identify and defend against malicious attacks and cascading failures, to provide early warning, and to prevent system-wide failures.

2.2 AUTONOMIC COMPUTING ABSTRACTIONS

A novel aspect of the AC vision is the goal of making decisions that take multiple perspectives into consideration. This can be accomplished with contextual analytics, which provide views of the system elements from various levels of abstraction.



Figure 2: Autonomic Computing Abstraction Levels

Figure 2 illustrates three different views of the same system elements, but with a variety of relationships within different contexts. The lower level abstraction views system elements as a stand-alone entity, and only considers the type of element and vendor specific informatics when diagnosing problems and selecting corrective action. The middle level abstraction looks at the aggregation of similar elements (e.g., a pool of servers) and would extend the diagnostics and problem resolution to consider things such as load balancing, disaster recovery policies, etc.

The top level abstraction takes on a very different perspective. In this example, the top level abstraction places system elements within the context of the corporate missions the system supports. One might place a higher priority on keeping lighter computing loads on mission critical system elements, rather than uniformly spreading computing loads across an enterprise-wide server farm.

2.3 AUTONOMIC COMPUTING CYBERNETICS

The AC design is built on the premise that one must be able to measure, make a decision, and control system elements at all of the abstraction levels (as described in the example in Section 2.2). This is called the AC control loop. Control loops are designed to provide the self-configuring, self-healing, selfoptimizing, and self-protecting capabilities.



Figure 3: Autonomic Computing Control Loop Component

Figure 3 illustrates the composition of the AC control loop monitor includes components. The sub-component mechanisms that collect, aggregate and filter element data (measures) from sensors associated with the specific element being controlled. The analyze sub-component is made up of mechanisms that model or analyze complex situations within the scope of the control loop. The plan sub-component decides the actions needed to achieve the desired goals and objectives. (Note : Analyze and Plan are used to support the "decide" phase of the AC control loop.) The decision logic has embedded "act, monitor and learn" functions, which verify the plan successfully solved the problem or achieved the desired outcome. The execute sub-component executes the actions planned, supporting the control phase of the AC control loop. The knowledge sub-component represents the KM associated with the controlled element, and continuously grows as it stores the information that's been measured, analyzed, planned, and executed - and the ensuing results.



Note that the AC control loop structure illustrated in Figure 3 has sensors and effectors at the top and at the bottom. This design provides the ability to manage a single system entity, a pool of entities, or the aggregation of multiple entities -- i.e., in

support of the various system levels of abstraction described in Section 2.2 and illustrated in the hierarchical figure above.

It should be noted that AC is not a product. It is a vision that can be implemented at various levels of automation (e.g., selfhealing and self-protection), and support many system level abstractions (e.g., resource pools or mission systems). As Information Technology (IT) matures, system elements have improved the information provided through "sensor" interfaces, and have increased the element commands that can be specified through "effector" interfaces to the system element.

3.0 BUILDING A SMARTER PLANET

The authors contend that Autonomic, which focused on enterprise systems management and large data centers, was the technical predecessor to the Smarter Planet initiative. Smarter Planet extends the scope of sensors well beyond the traditional system elements (e.g., servers, storage, networks, etc.) and applies advanced analytics to support a much broader set of informatics, inter-related abstractions (societal areas) and cybernetics. The authors recognize there were numerous other technical and non-technical advances that contributed to the evolving Smarter Planet campaign.

Whereas Autonomic Computing acted on informatics provided from system elements, Smarter Planet's cybernetics approach is to act on informatics from any type of data source – ranging from a utility meter or pressure sensor on a bridge, to mobile The Smarter Planet cybernetics is built on three tenets:

passive micro-chips embedded in a pet or human being.

- 1. **Instrumented**: anything with a sensor can be an **Informatics** element. As previously described some sensors are uni-directional (they only provide data, or they simply accept commands). The more useful elements are bi-directional and do both!
- 2. Interconnected: A smarter planet sensor must be interconnected (preferably to the internet, or a hub computer w/ access to the internet), otherwise one loses a tremendous amount of automation by having to include a human in the loop (to read the data and enter it into the system). Some sensors need their data to be converted (e.g., analog to digital, or proprietary representations to industry standard representations).
- 3. **Intelligent:** And a smarter planet solution is built on intelligent processing (**Cybernetics**) exploiting advanced analytics to optimize effectiveness and efficiencies from every possible perspective



Figure 5: Intelligent Operations Center (IOC)

The Intelligent Operations Center (IOC) is the framework that enables the Smarter Planet to leverage different types of sensors (instrumented sensors and data sources), integrate the sensor data (provide interconnectivity), apply advanced analytics (intelligence) and then define and automate the smarter cybernetics. Like the AC Control Loop Component, it supports the closed-loop cycle to the degree supported by the associated sensor instrumentation.

In the speech Palmisano gave at the Council on Foreign Relations in New York City on November 6, 2008, he discussed IBM's Smarter Planet vision – a new strategic agenda for progress and growth. Palmisano outlined the premise of a smarter planet and the coming of age of a whole new generation of intelligent systems and technologies—more powerful and accessible than ever before.

It provided a way for industries, infrastructures, processes, cities and entire societies to be more productive, efficient, and responsive. Given the data explosion and computing advances of the previous millennium, Palmisano believed there was an opportunity to address the problems and challenges that were gripping the world during 2008. A world capable of making more intelligent decisions—from smarter power grids, to smarter food systems, smarter water, smarter buildings, smarter healthcare, and smarter traffic systems.

Palmisano recognized that everything (including cars, power grids, transportation, phones, etc.) was becoming more instrumented and interconnected. This technology phenomenon produced more volumes, velocity, variety, and veracity (four Vs of Big Data) of information and data being captured than ever before.

By 2010, governments and multistries were not longer questioning on Systemics, availability, and informatics (WMSCI 2014). The portfolio of the Smarter Planet vision nor values - they were looking for knowledge and experience on how to create Smarter Planet solutions. Some of these are included in the figure below.



Figure 6 - Smarter Planet Building Blocks

On January 12, 2010, Sam Palmisano kicked off the new year and decade with a follow-up to the Smarter Planet speech with a new speech called "The Decade of Smart" at the Chatham House in London, England which evolved the Smarter Planet initiative into a multiplatform strategy promoting the way in which IBM technology and know-how helps industry, government, transportation, energy, education, healthcare, cities, and other businesses work smarter and contribute to building a smarter planet. Sections 3.1 and 3.2 describe the more mature "Smarter Buildings" and "Smarter Cities" solutions in more detail.

3.1 SMARTER BUILDINGS

In the U.S., buildings consume 70% of all electricity, up to 50% of which is wasted. Commercial buildings lose as much as 50% of the water that flows into them. By 2025, buildings will be the single largest energy consumers and emitters of greenhouse gasses on our planet. [8] In an attempt to reduced buildings wasted resources - over the last decade, building owners have installed smart sensors and control systems that can detect and sense various conditions and emit alerts or responses of many disparate systems. These efforts have only lead to minimal costs savings. The challenge for many building owners is how do you collect the Big Data 4V's from the silo information to provide operational and performance improvements in the building. This is a comprehensive effort because most of the building systems (energy, heating, lighting, water, security and other specialized systems) operate independently, through a mix of vendors, and have different protocols and transport mechanisms.

Building managers think and manage buildings along three dimensions: energy, operations, and space. They need to know where are opportunities to save energy; identify operational and/or capital improvements; and ability to optimize utilization of buildings space. The IBM Smarter Building solution solves these building managers' problems by addressing these key challenges: energy and asset management, building operations management, and effective space utilization. The IBM Smarter Building solutions set has the following main areas:

Energy management - energy management is the realtime monitoring of building and data center equipment. It reduces energy consumption and waste over the life cycle of a building and increases facility performance in a sustainable manner.

Operations management - operations management includes asset management and performance, utilization, building assets is optimized through asset visibility and operations management.[8]

As shown in Figure 7 - the IBM Smarter Building solution was built and designed around the elements of visualization. intelligence, interconnected, instrumented, and physical. These solution capabilities enable building managers to: integrate and optimize the physical and digital infrastructure of buildings; create facilities that are more cost-effective, operationally efficient, productive, safe, secure, and environmentally responsible; gather data, manage assets, monitor sensors, centralized analytics optimization; and distributed control. These Smarter Building solution capabilities will enable the integration of a city's buildings. When interactions between a city and buildings exist, the buildings can contribute to the health of the city. The city as a whole can reduce energy consumption and carbon dioxide (CO2) emissions by 50-70%, energy usage reduced by up to 40%, maintenance cost 10-30%, and save 30-50% in water usage.



Figure 7 – Smarter Building Architecture Elements

3.2 SMARTER CITIES

Governments and business are faced with shrinking budgets and limited resources but need to meet demanding pressures to improve energy consumption, traffic gridlock, aging infrastructure, healthcare services, financial markets, food production, etc. to spur economic growth and improve quality of life for citizens. Government officials couldn't meet these challenges because most critical information is often stored in disparate systems across disconnected departments, hindering a clear view of the operational picture and increasing the difficulty of coordinating agency efforts. Without a single, integrated view of events, incidents or impending crises, and without the ability to rapidly share information, a city might be unable to effectively deliver services in a sustainable fashion, protect citizens or drive future economic growth. [10]

Government officials and industry involved in city development or federal response services have applied a variety of IOCbased solutions that provide a centralized operations dashboard to help city leaders gain insight into various aspects of city management or federal responses. The centralized operations dashboard spans agencies and enables drill-down capability into underlying agencies, such as emergency management, public safety, social services, transportation, or water. This approach enables cities to manage large complex environments,

communicate more effectively deploying resources.

These IOC capabilities provide leading cybernetic technologies where systems are involved in a closed signaling loop; that is, where action by the system generates some change in its environment and that change is reflected in that system in some manner (feedback) that triggers a system change. This solution offers integrated data visualization, real-time collaboration and deep analytics that can help city/federal agencies prepare for problems before they arise and coordinate and manage problems as they occur, to enhance the ongoing efficiency of city operations. Executive dashboard capabilities give decision makers a real-time, unified view of operations so they can see who and what resources are needed and available. Cities, federal agencies, and industry can share information instantly across agency lines to accelerate problem response and improve project coordination. [9]

In the past, individual city agencies often focused only on their own operations and were unable to share information with other agencies and departments. The IOC is designed to help multiple agencies and departments share information — such as metrics, events and processes — and collaborate in near-real time, allowing cities to better anticipate and respond to situations while optimizing limited resources.



The IOC framework has been successful implemented in various Smarter Cities world-wide. For instance – the city of Rio de Janeiro teamed with IBM to develop a Smarter City solution – Rio Operations Center that provides city officials with new capabilities to further improve the city's emergency response system, and give citizens access to information that will help them better manage their daily lives. Since opening less than a year ago, the Rio Operations Center has integrated information and processes from across 30 different city agencies into a single operations center that provides a holistic view of how the city is functioning on a 24 by 7 basis. The Operations Center serves as the nerve center for the city, applying analytical models developed by IBM to more effectively predict and coordinate reaction to emergency incidents. [10]

"In Rio de Janeiro, we are applying technology to benefit the population and effectively transitioning to a smarter city," said Mayor of Rio de Janeiro Eduardo Paes. "In addition to using all information available for municipal management, we share that data with the population on mobile devices and social networks, so as to empower Operations officials from across the city now collaborate daily to manage the movement of traffic and public transportation systems, and the efficiency of power and water supplies. The Center also relies on a system pioneered by IBM Research scientists -- a high-resolution weather forecasting and hydrological modeling system for Rio de Janeiro, which can predict heavy rains up to 48 hours in advance. The forecasting system is based on a unified mathematical model of Rio that pulls data from the river basin, topographic surveys, the municipality's historical rainfall logs, and radar feeds. The system predicts rain and possible flash floods, and has also begun to evaluate the effects of weather incidents on other city situations such as city traffic or power outages.

4.0 CONCLUSIONS

We have seen tremendous advances in data processing (computer) technology in the last half century. There were three major technology advancement waves that essentially defined computing in the enterprise. In the 1960s, the advent of the IBM System 360 revolutionized business processes "back office" management - introducing automated systems management. The 1980s transformed the computing power of earlier mainframes to considerably smaller computers, which were ultimately named "personal computers" (PCs). The PC's "client-server" computing model provided employees across the enterprise considerably more autonomy -- e.g., not being required to be connected to the "back-end system" and the versatility that came with new PC applications. And we then saw the birth of the World Wide Web in the 1990s and early 2000s, as the Internet evolved, was commercialized, was a catalyst to the creation of e-Business.

We are likely on the cusp of a fourth wave, which is characterized by the confluence of Big Data, Advanced Analytics, Social Computing, Mobile Computing, and Cloud Computing. This confluence of technologies (sometimes referred to as the Internet of Things) is again transforming the way companies world-wide deliver and consume millions of systems, software and services. The confluence of these technologies is enabling four mega-trends (each with significant societal implications, and advanced capabilities enabling a Smarter Planet):

"Growing Scale / Lower Barrier of Entry: A massive expansion in the number of smart devices, sensors, transactions and users of digital technologies is creating huge amounts of structured and unstructured data - while the rise of easy-to-use and affordable programming interfaces is simultaneously lowering the barrier of entry for companies to create applications and services that derive value from this data. Increasing Complexity / Yet More Consumable: While the volume, variety, velocity, and veracity of data is contributing to the increasing complexity of data management and workloads - creating a greater need for advanced analytics to discover insights - mobile devices have made technology more consumable, creating user demand for interactive tools for visual analytics. Fast Pace: Change is coming faster than ever disruptive models for the development and consumption of

technology are emerging to penetrate global enterprise ecosystems, resulting in rapid innovation and decreased time-to-value. Open online courses are experiencing exponential growth making education and training more accessible. devices and the explosive growth in structured and unstructured data are causing information and contextual overload. With the increasing affordability and sophistication of smart devices, new opportunities exist to provide contextually aware and personalized services based on user views, desires, preferences and location, delivered just-in-time." [11]

Technology today is what's enabled the Smarter Planet initiative. One could have conceptually described the value of the many Smarter Planet views in the past; but one could not have had a pragmatic discussion as to how to implement it in the last millennium. The world is flat, connected, and global. The world is evolving at a rapid pace. The World Health Organization (WHO) estimates that the majority of the world population now lives in a city

"Urbanization, the demographic transition from rural to urban, is associated with shifts from an agriculture-based economy to mass industry, technology, and service. For the first time ever, the majority of the world's population lives in a city, and this proportion continues to grow. One hundred years ago, 2 out of every 10 people lived in an urban area. By 1990, less than 40% of the global population lived in a city, but as of 2010, more than half of all people live in an urban area. By 2030, 6 out of every 10 people will live in a city, and by 2050, this proportion will increase to 7 out of 10 people. Currently, around half of all urban dwellers live in cities with between 100 000 - 500 000 people, and fewer than 10% of urban dwellers live in megacities (defined by UN HABITAT as a city with a population of more than 10 million)." [12]

The perdurable world-wide migration from urban settings to cities fuels the need for a Smarter Planet. It is estimated that: Smarter traffic systems can cut gridlock by 20%; and

Smarter energy systems can reduce energy waste by 15% or more. The perpetual increase in size and complexities of cities and mega-cities makes it essential for governments to adopt smarter approaches and smarter technology. The industries that have emerged around smarter buildings, and smarter energy (e.g., Energy Service Companies and Energy Management Systems) provide evidence that the world is moving in this direction.

Globally, urban growth peaked in the 1950s, with a population expansion of more than 3% per year. Today, the number of urban residents is growing by nearly 60 million every year. The global urban population is expected to grow roughly 1.5% per year, between 2025-2030. By the middle of the 21st century, the urban population will almost double, increasing from approximately 3.4 billion in 2009 to 6.4 billion in 2050. Almost all urban population growth in the next 30 years will occur in cities of developing countries. Between 1995 and 2005, the urban population of developing countries grew by an average of 1.2 million people per week, or around 165 000 people every day. By the middle of the 21st century, it is estimated that the urban population of these counties will more than double, increasing from 2.5 billion in 2009 to almost 5.2 billion in 2050" [12]

Emerging countries and the rate at which some have grown further validate this confluence of technology; but more importantly, they also present a very interesting opportunity. The cost of "modernizing" a long standing, well established city will notionally cost more than building a smart city "starting from scratch." But starting from scratch is not an option for a city that depends on infrastructure, governance, and the many

Contextual Overvoad: of the prohleration of sensors and on Systemics, Systemics Scheretins and Informatics (WMSGI 2014) nold during a rebuilding exercise. The opportunity is there for emerging countries to make intelligent decisions in the design and development of cities - e.g., making early investments in instrumentation, interconnectivity, and ultimately intelligent systems that could help these countries "leap frog" the older technologies and processes that many cities today are in the process of modernizing.

> This paper provided a variety of perspectives on the Smarter Planet initiative, the many underlying technologies that make it possible today, and the underlying academic concepts from the field of informatics and cybernetics that have guided its evolution. This paper only discussed a subset of the many industries and "smarter solutions" that have blossomed in the last several years. The next generation of Smarter Planet systems will inevitably exploit other advanced technologies, such as Cognitive Computing [5] Imagine the ability to have a bi-directional discussion with a Smarter Planet system that can reason and adjust itself as it learns from its empirical data and augments the data with human guidance.

ACKNOWLEDGEMENTS

The authors wish to thank Kevin Brown (Solution Architect, IBM Federal CTO Office) and David Jenkins (Executive Architect, IBM Federal CTO Office) for their technical review comments and discussions.

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Fostering Interdisciplinary Collaboration to Improve Student Learning

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ABSTRACT

The purpose of this study was to compare the impact on student learning of those enrolled in courses where instructors participated in collegial coaching and peer mentoring. A nonequivalent group design methodology was employed along with an analysis of variance to analyze data. Findings indicated higher mastery levels of student learning outcomes, higher levels of perceived critical thinking and collaboration by students, statistical significance in critical thinking constructs, higher levels of persistence, and more A's and B's and fewer D's and F's in courses where faculty members were mentored as compared to courses where faculty members were not.

Keywords: Interdisciplinary Collaboration, Student Learning, Collegial Coaching, Mentoring

INTRODUCTION

Several professors involved in the university Quality Enhancement Plan decided the best way to ensure successful implementation of Team-Based Learning [1], a common instructional strategy used across multiple disciplines, was to support each other through collegial coaching. They had face-to-face meetings each week to discuss lessons learned, shared resources, and communicated via email and blogs. They also sought out support from the project director when needed. Their efforts were the impetus for mentoring along with coaching that would result in improved collaboration and student learning.

The subsequent mentoring and coaching promoted exploration, critique, and reflection to transform practice [2]. There was no preaching; only thoughtful, reflective questions aimed at guiding colleagues to the answers they sought. Collegial coaching created an environment of openness for peer mentoring. Professors provided each other advice, support, and encouragement by leading and guiding by example. They engaged in collaborative practices to enhance teaching and learning relative to the implementation of Team-Based Learning. They also frequently attended professional development activities with follow-up discussion [3].

Coaching and peer mentoring facilitated effective professional development and helped break down the cycle of instructor

isolation. It also served as a communicative structure that allowed the flow of information to instructors regarding the Team-Based Learning techniques that were working [4]. Coaching sessions were productive conversations between faculty concerning student learning. They also served as acknowledgement of small wins as new innovations were being implemented [5]. Sessions fostered collegial teams that stimulated content innovation.

The collegial coaching method utilized for this project was based on a collaborative mentoring strategy called Learning Walks. Learning Walks are a professional development process designed to support thinking about instructional practice. They are designed to raise questions and promote self-reflection. The process leads to an instructional community concentrated on the examination of practice with no hidden agendas [6]. The project director introduced Learning Walks and provided training to peer mentor participants.

CONCEPTUAL FRAMEWORK

Learning Walks

Learning Walks [6] are a form of collegial coaching that provide a structure for interprofessional collaboration and were designed to help establish a common understanding of practice about the delivery of Team-Based Learning. Learning Walks help to open classroom doors and provide a collaborative professional culture offering a method for professional reflection. The focus of Learning Walks is on questioning strategies, classroom ecology (student-student & student-instructor interactions) and active student engagement.

A team consisting of 2 to 3 novice instructors, plus a veteran instructor, conducted classroom visitations twice a semester. Reflective questioning was used as a way to initiate dialogue about teaching and learning, as a way to look back at what happened and what was learned, and a way to look forward and resolve challenges that may arise. The classroom visitation phase of Learning Walks consists of four steps [6]:

 Preparation. Including: a) Assembly of members of the Learning Walk team, b) Discussion of the Team-Based Learning Scorecard [7], c) Discussion of student learning outcomes, and d) Determination of the type of evidence required for mastery of learning outcomes.

- 2. The classroom visit. Team members: a) enter the classroom at the same time, b) do not speak to each other during the classroom visit, c) remain unobtrusive, but may speak with student or look at their work, and d) observe student-student and student-teacher engagement.
- 3. Team debriefing. Team members ask: Were students engaged in meaningful learning? b) Were higher order thinking and collaboration addressed? c) Were studentlearning outcome(s) addressed?, and d) Was there something you observed that you would use in your classroom?
- 4. Closing Conversation between mentor and instructor. Mentor asks: Did it go as planned? b) Would you do anything differently? and c) What was observed. The conversation concludes with a discussion of ideas, strategies, and/or techniques that can be used in future classes.

Peer Mentoring

The growth of any craft depends on shared practice and honest dialogue among the people who do it. We grow by trial and error, to be sure—but our willingness to try, and fail, as individuals is severely limited when we are not supported by a community that encourages such risks [8, p. 144]. Engaged professionals who collaborate in learning teams hold themselves to a higher standard, improve their practice, and lift student achievement [9]. Instructors were divided into teams representing several disciplines across campus. They also received Learning Walk training.

Peer mentoring was defined as collaboration between experienced person who provides information, advice, support, and encouragement to a less experienced colleague by leading and guiding by example. Mentors engaged in an active, collaborative, year-long program aimed at enhancing teaching and learning through regular coaching, mentoring, and professional development activities. Mentors asked thoughtful, reflective questions that helped guide colleagues to the answers they sought. The purpose of mentoring was to provide a supportive environment for members of the improvement plan, facilitate collegial coaching, stimulate scholarly dialogue, provide assistance and opportunities for professional growth, provide opportunities for practice and guidance pertaining to the acquisition of Team-Based Learning strategies in a non-evaluative environment, and to develop learning communities constructed around professional improvement.

Mentors invited member of their cohort into their classroom for observation and coaching, organized and facilitated discussion sessions, and coordinated Learning Walks as relative to the implementation of Team-Based Learning. They were asked to be good listeners, avoid situations with other members of the cadre that they were not qualified to deal with or direct them to someone who could, be approachable, available, follow up on commitments, be realistic and encouraging, maintain confidentiality, and maintain accountability throughout the mentoring process. Most importantly, mentors were asked to coach and not judge [10].

Mentoring required a substantial time commitment to attend training and to facilitate Learning Walks. As a gesture of appreciation, mentors were allocated up to \$1,000 for presentations at peer-reviewed professional conferences. Mentors also received training and support from the project director. Furthermore, those involved as mentors received a special Certificate of Collegial Coaching and Mentoring.

Team-Based Learning as a Common Pedagogy

Team-Based Learning [1] is a special form of collaborative learning using a specific sequence of individual work, group work and immediate feedback to create a motivational framework in which students increasingly hold each other accountable for coming to class prepared and contributing to discussion. Team-Based Learning was the common instructional strategy utilized by those who participated in the Quality Enhancement Plan. It was selected prior to the initiation of the plan by an advisory committee based on a review of student assessment data.

Deutschlander, Suter and Lait [11] developed a model for interprofessional education called the *IP Enhancement Approach*. This approach was developed to improve program reach, implementation and sustainability. It included the use of existing class schedules along with common content, pedagogies or instructional techniques. One could consider the use of Team-Based Learning as an IP Enhancement since it was used as a common pedagogy linking multiple disciplines to boost problem-solving, decision making and higher order thinking required for interdisciplinary endeavors.

Team-Based Learning Scorecard. Michaelsen and Sibley [7] developed a scorecard to help ensure fidelity of Team-Based Learning implementation. This scorecard was used as a collective starting point to stimulate conversation leading to observation of classes and subsequent discussion. The scorecard addressed focus, team formation (selection, composition and process), orientation of students (rationales and grade weights), readiness assurance process (frequency, focus of questions, feedback, appeals and link to activities), activities and application assignments (problem significance/relevance, problem selection, deliverables and reporting), individual accountability (accountability to instructor and peers), and team accountability (impact of team assignments and feedback on team assignments).

METHODOLOGY

This was a descriptive quantitative study framed by a modified action-research cyclical framework beginning with data collection, initiation based on the data, evaluation of outcomes, revisions; and finally a continuous planning, acting, and evaluating cycle. The study explored differences between variables in mentored and non-mentored courses. Student assessments utilized in this study included the Student Learning Target Mastery Report, Critical Thinking and Collaboration Pre- and Post-Tests, and the California Critical Thinking Skills Test (CCTST). Withdrawal and grade distribution data were also gathered from the university data management system and utilized for analysis. Additionally, the faculty feedback survey contained three questions pertaining to mentoring and collaboration.

Research Questions

This study examined student achievement in courses where faculty were mentored as compared to courses where faculty were not mentored. The research questions guiding the study included:

- RQ 1: Will faculty members perceive mentoring as having a positive impact on relationships, communication and collaboration with their colleagues?
- RQ 2: Will there be a difference in mastery of student learning outcomes in courses where faculty members were mentored/coached as compared to student learning outcome mastery in courses where faculty members were not mentored/coached?
- RQ 3: Will there be a difference in perceived levels of critical thinking and collaboration among students enrolled in courses where faculty members were mentored/coaches as compared to courses where faculty members were not mentored/coached?
- RQ 4: Will there be a difference in critical thinking constructs in courses where faculty members were mentored/coaches as compared to courses where faculty members were not mentored/coached?
- RQ 5: Will there be a difference in student persistence in courses where faculty members were mentored/coached as compared to courses where faculty members were not mentored/coaches?
- RQ 6: Will there be a difference in student grades in courses where faculty members were mentored/coached as compared to courses where faculty members were not mentored/coached?

Participants

Mentoring participants consisted of 17 self-selected instructors from the colleges of Allied Health, Arts and Sciences, and Continuing Education. Four mentoring participants (23.5%) were male and 13 (76.5%) were female. Mentoring participants served 543 students in 22 undergraduate and graduate classes. Non-Mentoring participants consisted of 33 instructors from the colleges of Allied Health, Arts and Sciences, Business, Continuing Education, Education, Engineering, Medicine, Nursing and the School of Computing. Fifteen (45.4%) non-mentoring participants were male and 18 (54.6%) were female. These instructors served 970 students in 46 undergraduate and graduate classes.

Assessments

Student Learning Outcome Target Mastery Report. The Student Learning Outcome Target Mastery Report consisted of 3-6 student-learning outcomes that were matched with assessments and a target mastery level, or benchmark, established by the instructor. These outcomes were connected with one of the four following domains: analyzing, applying, creating, or evaluating. The report was developed by instructors and submitted to the project director for feedback at the beginning of the semester. At the end of the semester, instructors reported the target mastery levels for each domain that were met and those that were not. A brief narrative was provided for all benchmarks that were not met including a rationale and improvement strategy. Student learning outcomes found in the Target Mastery Report were based on higher order thinking aligned with Bloom's Taxonomy of Revised Cognitive Domains [12].

Critical Thinking and Collaboration Pre- and Post Tests. The Critical Thinking and Collaboration Pre- and Post-Tests consisted of 20 likert scale survey questions. Likert questions used the following rating scale: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree. Nine questions pertained to critical thinking and 11 pertained to collaboration. For both critical thinking and collaboration, the respective items were summed and then divided by the total number of scores to get a mean score in each domain. Students enrolled in participant courses were sent the survey at the beginning and again at the end of the semester using a web-based software system called Class Climate.

California Critical Thinking Skills Test. The California Critical Thinking Skills Test, created by Insight Assessment [13], is a standardized test normed with other four-year universities located in the United States. It was administered at the end of the semester. The California Critical Thinking Skills Test provides return scores on the following scales: analysis, evaluation, inference, deduction, induction, interpretation, evaluation, and overall reasoning skills.

Persistence and Grade Reports. Persistence was determined through the calculation of course withdrawals of students enrolled in the mentoring participants' courses and non-mentoring participants' courses. Course grades were obtained and utilized to compare grades from the mentoring participants' courses and non-mentoring participants' courses.

Faculty Feedback Survey. The Faculty Feedback Survey consisted of 4 sections, 1) Project Overview, 2) Instructor Recognition and Professional Development, 3) Implementation of Team-Based Learning, and 4) Project Improvement. Each section of the survey contained both Likert and open-ended questions. Likert questions used the following rating scale: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree. Items cited in the findings of this study were contained in the Project Overview section.

Data Analysis

Descriptive statistics were reported for items in the Faculty Satisfaction Surveys, Student Learning Outcome Target Mastery Report, the Critical Thinking and Collaboration Preand Post-Tests, and the California Critical Thinking Skills Test. Other various analyses including Pearson chi-square tests, one-way analysis of variance (ANOVA) tests, and a one-way multivariate analysis of variance (MANOVA) were conducted. Appropriate tests were selected for each research question to determine statistical significance of items found in these assessments.

FINDINGS

Faculty Perceptions of Mentoring

As seen in Figure 1, there were three questions pertaining to the mentoring experience included on the faculty satisfaction survey administered at the end of the academic year. Mean scores indicate positive perceptions of mentoring/coaching for all three items with scores approaching o exceeding a score of 4.0.



Figure 1. Faculty Satisfaction Survey Results, N = 17. The minimum score was 1.0 and the maximum score was 5.0 on all three items.

Mastery of Student Learning Outcomes by Faculty Group To complete the Student Learning Outcome Target Mastery Report, instructors developed student-learning outcomes addressing higher order thinking skills, linked each one with appropriate assessments and then determined whether mastery levels were met. Data were disaggregated by Cognitive Domains (analyzing, applying, creating, and evaluating) relative to higher order thinking found in Bloom's Revised Taxonomy [12]. Comparisons of categorical variables were made using Pearson chi-square tests. As seen in Table 1, the percentages of mastery levels met were significantly different for each domain. Mentoring/coaching participants' courses reporting higher levels of mastery level percentages met were: analyzing, χ^2 (1, N = 681) = 91.52, p < .01; applying, χ^2 (1, N = 454) = 63.80, p < .01; creating, $\chi^2 (1, N = 500) = 19.31, p < .01$.01; and overall mastery, χ^2 (1, N = 500) = 62.60, p < .01. In the evaluating domain percentages were also significantly different. However, percentages of mastery levels met were higher for non-mentoring/coaching participants' courses, χ^2 (1, N = 468) = 102.12, p < .01.

Table 1

Student Learning Outcome Target Mastery Percentages

	Group 1	Group 2	
Cognitive Domain	% Met	% Met	
Analyzing	84.4	47.6	
Applying	97.0	70.5	
Creating	95.2	82.6	
Evaluating	19.7	70.7	
All Domains	81.0	65.3	

Note. All percentages significant at the .01 level. Group 1 = Mentored/Coached, Group 2 = Non-Mentored/Coached

Critical Thinking and Collaboration Scores by Faculty Group

Students in courses with mentored/coached and nonmentored/coached faculty completed a critical thinking and collaboration pre- and post- test. Because pre- and post-test scores could not be matched, these scores were treated independently. A one-way analysis of variance (ANOVA) was conducted to determine differences between mentored and non-mentored group scores, differences in pre-and posttest scores, and the interaction of these two variables for both critical thinking and collaboration. Each will be discussed below.

Critical Thinking. Results of the one-way ANOVA indicated no difference in critical thinking scores based on group, F(1, 3) = .51, p = .30. A statistically significant difference in pre- and post-test critical thinking scores was found regardless of group, F(1, 3) = 5.32, p = .01. Additionally, a significant interaction was found between mentored/coached and non-mentored/coached group and pre- and post- tests, F(1, 3) = 5.36, p = .01. As evidenced in mean score data presented in Table 2, the mentored/coached group's critical thinking post-test scores showed significant improvement as opposed to the non-mentored/coached group.

Table 2

Critical Thinking Pre- and Post-Test Mean Scores

Mean	Std. Deviation
3.57	.65
3.83	.70
3.74	.66
3.74	.74
	Mean 3.57 3.83 3.74 3.74

Note. The minimum score was 1.0 and the maximum score was 5.0 on both the pre-and post-test. Group 1 = Mentored/ Coached, Group 2 = Non-Mentored/Coached

Collaboration. Results indicated no difference in collaboration scores by group, F(1, 3) = .22, p = .64. However, pre- and post-test collaboration scores were significantly different regardless of group, F(1, 3) = 19.03, p = .01. Additionally, there was a statistically significant interaction between mentored/coached and nonmentored/coached groups and pre- and post- tests with the mentored/coached group having significantly higher levels of improvement in pre- and post- test collaboration scores over the non-mentored/coached group, F(1, 3) = 3.50, p = .02. As seen in Table 2, while both mentored/coached and nonmentored/coached groups showed improvement in mean scores on post-tests, mean collaboration scores for the mentored/coached group were much better than those of the non-mentored/coached group.

Table 3

Collaboration Pre- and Post- Test Mean Scores

Group	Test	Mean	Std. Deviation
1	Pre	3.26	.69
	Post	3.55	.68
2	Pre	3.35	.80
	Post	3.43	.84

Note. The minimum score was 1.0 and the maximum score was 5.0 on both the pre-and post-test. Group 1 = Mentored/Coached, Group 2 = Non-Mentored/Coached

Critical Thinking Constructs by Faculty Group

The California Critical Thinking Skills Test (CCTST) was administered at the end of the semester to measure the critical thinking skill level of each student. The CCTST measures test-taker's reasoning skills on the following scales: induction, deduction, analysis, inference, evaluation, interpretation, explanation, and overall reasoning skills. Students in both the mentored/coached faculty courses as well as the nonmentoring/coached faculty courses were asked to take the A one-way multivariate analysis of variance CCTST. (MANOVA) was conducted to determine whether a difference existed in critical thinking scales in courses where faculty members were mentored/coached as compared to courses where faculty members were not mentored/coached. Results indicated a statistically significant difference in scales based on group course placement CCTST (mentored/coached or non-mentored/coached), Pillai's Trace = .258, F(7, 45) = 2.24, p = .05. The univariate F tests showed there was a statistical difference between mentored/coached and non-mentored/coached group scores for deduction, F = 12.25, df = (1), p = .01; analysis, F = 5.91, df = (1), p = .02, and inference, F = 12.87, df = (1), p = .01. Table 4 provides means and standard deviations for each of the CCTST scales.

Table 4

CCTST Scale Mean Scores

Subscale	Group	N	Mean	SD
Induction	1	19	75.92	8.79
	2	34	73.39	6.93
Deduction	1	19	74.82*	6.43
	2	34	68.72*	5.88
Analysis	1	19	74.74*	6.12
	2	34	70.44	6.20
Inference	1	19	77.01	4.13
	2	34	71.26	6.25
Evaluation	1	19	71.73	9.94
	2	34	68.29	7.23
Interpretation	1	19	77.76	10.68
	2	34	74.19	7.92
Explanation	1	19	72.63	12.56
	2	34	68.65	8.83

Note. All scores are on a 100-point scale. * indicates

significance at p < .05. Group 1= Mentored/Coached, Group 2 = Non-Mentored/Coached

Additionally, reports provided from Insight Assessment [13] compared group (mentored/coached or nonmentored/coached) scores to an aggregate sample of CCTST Four Year College Students. The assessment indicated that student scores within the mentored/coached faculty group were in the 37th percentile while student scores within nonmentored/coached faculty group were in the 20th percentile.

Student Persistence by Faculty Group

Student withdrawal rates were calculated for all courses in the study. A Pearson chi-square test was conducted to determine if course withdrawal rates were significantly different based on faculty group (mentored/coached or non-mentored/coached). Results of this analysis show no difference of withdrawal rates by group, χ^2 (1, N = 1511) = .89, p < .35. Although no significant difference was found, there was a slight decrease in course withdrawals with 2.3% (N = 13) in mentored courses and 3.1% (N = 29) in non-mentored courses.

Student Grades by Faculty Group

Student course grades were obtained and utilized to determine whether course grades differed by faculty group (mentored/coached or non-mentored/coached). A Pearson chi-square test was conducted and indicated no difference of course grades by group, χ^2 (4, N = 1489) = 2.21, p < .70. While only one faculty group received mentoring, both groups were trained on Team-Based Learning, which is an evidence-based instructional strategy. The lack of statistical significance may be a result of training and recurring professional development geared toward improving instruction.

CONCLUSIONS

In this study, student critical thinking and collaboration competencies, student persistence, student grades and faculty perceptions were compared between two groups of faculty members participating in a university-wide improvement plan called a Quality Enhancement Plan (QEP). One group, consisting of 17 faculty members, participated in peer mentoring and coaching using a collegial coaching strategy called Learning Walks. The other group, consisting of 33 faulty members, participated in the QEP but received limited mentoring only by the project director.

Walks were the focal point of the Learning mentoring/coaching strategy. The strategy helped faculty members develop collegial relationships through structured classroom visitation and conversation centered on the pedagogical use of Team-Based Learning. Mentors served as facilitators of 2 to 3 faculty instructors who remained together in the same group all year. They engaged in reflective questioning with members of the group, and helped them develop and internalize instructional improvement personalized to their individual needs. Learning Walks, along with similar strategies called walkabouts, instructional walks, and focused walks, are not commonly used in university settings and represent a new way to foster professional dialogue and learning communities meant to enhance classroom instruction and student learning.

Although statistical significance was not found throughout all of the assessment data, overall, findings indicated higher assessment scores in courses where faculty participated in peer mentoring and coaching. The lack of significance may be a result of the informal mentoring that took place between instructors and the project director, and between each other during numerous professional development activities held throughout the year. Fidelity of implementation may have also been a factor as there was no system of checks and balances to ensure compliance with the Learning Walk model. Additionally, course grades may have improved in both groups because they utilized the same instructional strategy, Team-Based Learning, which has been shown to improve grades in several studies [14, 15, 16].

Faculty indicated that mentoring improved interdisciplinary relationships, and fostered interdisciplinary communication and collaboration. These findings are consistent with similar research that found faculty peer mentoring beneficial [17, 18, 19]. Utilization of Learning Walks at the university level represents a promising method for instructional improvement. As a result, this method of mentoring and coaching should be furthered explored through additional research.

Moreover, Team-Based Learning, because of the use of application activities as culminating instructional events, may be employed as a common instructional strategy across multiple disciplines to enhance interprofessionalism and interdisciplinarity. Team-Based Learning application activities are designed around instructional techniques using case studies or scenarios with embedded problems and decision points to facilitate enriched discussion, collaboration and higher order thinking. The comprehensive nature of this types of application activity implies the integration of content from multiple disciplines.

RECOMMENDATIONS FOR FUTURE RESEARCH

It is recommended that this study be replicated in other university settings to help assess the effectiveness of the peer mentoring/coaching model used in this study. It is also recommended that the study go beyond instructors participating in university improvement plans and include those in the other general faculty populations.

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AN INTER-DISCIPLINARY LANGUAGE FOR INTER-DISCIPLINARY COMMUNICATION: ACADEMIC GLOBALIZATION, ETHOS, PATHOS, AND LOGOS

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ABSTRACT

Inspired by the intersection of character, emotions, and logic, much like a Hungarian Rhapsody which is beautifully sad; this paper explores ethos, pathos, and logos in the context of Academic Globalization. As students of the world, an inter-disciplinary language is pivotal for inter-disciplinary communication.

Given that the current state of the world stems primarily from miscommunications, it is imperative to launch a cognitive language tool which underscores global commonalities and mitigates cultural differences. Such a platform would foster interdisciplinary research, education, and communication.

New paradigms would evolve, grounded in ethos, pathos, and logos. Like yin and yang, these states are interrelated, interacting, and interchanging learning spheres. Just as day and night blend at some point; just as the Parthenon epitomized Greek thought, celebrated the birthplace of democracy, and for the first time, depicted everyday citizens in friezes- underscoring their impactful role- ethos, pathos, and logos represent cross-disciplinary communication devices which synergistically transform and ignite academic globalization.

The Literature Review links the concepts of ethos, pathos, and logos with the seminal work Lewis and his LMR framework, which has given birth to Cultureactive and subsequently to ICE [InterCultural Edge]. <u>http://www.fuqua.duke.edu/ciber/programs/</u> we_organize/ice/ Accessed February 14, 2014



PROPOSITION

Particularly relevant to this paper is the fact that the Parthenon columns are slanted inwards, and if extended into the sky, would intersect at about one mile above the earth. This extension beyond traditional thought and subsequent intersection represent character/credibility (ethos), emotion (pathos), and logic (logos). Moreover, Lewis' LMR framework, i.e. Linear-active, Multi-active, and Reactive, are the vehicle for an inter-disciplinary language which enables interdisciplinary communication.

In conclusion, this paper suggests that extending the LMR framework beyond conventional boundaries provides the foundation for inter-disciplinary language inter-disciplinary fosters and thus communication. Ethos, pathos and logos accelerate a rich communication platform, within context Academic the of Globalization.

Keywords: Globalization, International Business, Culture, Strategic Management, Communication, Leadership, Decisionmaking

LITERATURE REVIEW

The origin of ethos, pathos and logos began over 2,000 years ago:

The Greek philosopher, Aristotle argued that persuasion can be divided into three categories: ethos, pathos and logos [18] & [19].

Ethos [Greek for character]

Ethical Appeal – Persuasion emanates from the credibility, authority, or reputation of the speaker or writer. An ethos-principled argument is characterized by an appeal based on ethics or credibility.

Pathos [Greek for experience or suffering] **Emotional Appeal –** Persuasion is grounded in sympathy, emotion, or instinct. A pathetic story conveys emotion and imagination such that the audience is empathetic with the values and beliefs of the speaker or writer.

Logos [Greek for word]

Logical Appeal – Persuasion rests with reason and refers to an argument's logical appeal. Of paramount importance is the internal consistency of an argument and supporting evidence, e.g. constructs such as if A, then B.

Of seminal importance is HOW something is communicated, not WHAT is communicated. To this end, a review of the LMR framework follows.

ICE PROVENANCE

ICE emerged from another cross-cultural assessment tool, Cultureactive when from a research perspective, validity and

reliability issues became increasingly paramount. Grounded in his forty-plus years of cross-cultural consulting, Richard Lewis, who authored When Cultures Collide [13] and The Cultural Imperative [14], was challenged to explain national, international and transnational business cultures. Poignantly, he conceived the LMR framework, which gave birth to Cultureactive and later ICE [24].

The 1980s propelled an acute demand for cross-cultural instruction, and Richard Lewis, the consultant, was approached repeatedly by multi-national clients for a new and practical cultural/national classification system. For years, crossculturalists had grappled with the problem of summarizing or simplifying national characteristics. Richard Lewis proposed that cultures could be classified simply and more comprehensively according to the three categories, comprising the LMR framework [13] & [14].

Linear-actives

Cultures which are task-oriented, plan, organize, schedule and pursue one thing at a time (e.g. Germans, Swiss).

Multi-actives

Cultures which are lively, loquacious, multitask, prioritize according to the importance or thrill of the event (e.g. Italians, Latin Americans, and Arabs).

Reactives

Cultures that prioritize courtesy and respect, listen quietly, and react carefully to proposals (e.g. Chinese, Japanese and Finns).

The strength of this framework is that it transcends previous works by focusing on the individual, rather than the nation-state as the unit of analysis. With no assumption of within-country homogeneity, the above hypothesis focuses on actors rather than nations. The focus of the LMR model is communication, which is often the impediment between and among cultures, and commensurately a key consideration in globalization.

Known as the ABC research team, Adair, Buchan and Chen [1] & [2] capitalized upon both Hall's [8] low context/high context communication tool and Triandis' [22] model of subjective culture to result in the theoretical underpinnings for ICE. The conceptual reconfiguration leveraged the works of Trompenaars [23], Holtgraves [11], Hampden-Turner [23], Thomas and Kilman [20], Yamagishi [25], and Bearden, Money and Nevins [3] in the evolution from the experientially-based Cultureactive to the theoretically-based ICE.

The contribution of this paper is the LMR linkage the celebrated to Greek philosopher, Aristotle, who classified the art of persuasion through ethos, pathos and logos. While the logos appeal was Aristotle's favorite, all three serve to elevate communication to the next aspirational level. Moreover, this trilogy was inspired by Greek thought, in similar fashion to the Parthenon. Aristotle argued for *writing effectiveness*; this paper argues interdisciplinary communication for effectiveness enhanced by another trilogy: the LMR framework.

Commensurate with exploring, expanding and energizing international education, interdisciplinary communication and globalization, the LMR framework equips academicians and practitioners with a vehicle for interdisciplinary language. The simplicity of Linear-active, Multi-active, and Reactive constructs trump prior theoretical frameworks for studving cultural differences, which have included the Kluckhohn-Strodtbeck [9], Trompenaars and Hampden-Turner [23], and most notably, Hofstede [10].

The provenance of Cultureactive and ICE are chronicled in more detail in an earlier paper [24]. ICE is a collaborative initiative between the Fuqua School of Business, CIBER, Richard Duke Lewis Communications, and Cultureactive.com. Cultureactive and ICE are web-based products that teach cross-cultural awareness in business settings bv focusing on individual cultural profiles which are then compared to national profiles using LMR the constructs. Participants may analyze personal assessments, team results and national cultural profiles. Research consortia have completed the requisite validity and reliability measures for ICE. and commensurate ICE teaching consortia have established a certified teaching network.

Capitalizing on the LMR framework and integrating the basic components of persuasion- ethos, pathos and logos- [18] & [19], in the spirit of the Parthenon, where the columns intersect above the earth, and projecting this consortium bevond traditional thinking, the following emerges, symbolic of interdisciplinary which is communication:



Proceedings of The 18th World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI 2014)





EQUALS





LMR CONSTRUCTS COUPLED WITH ETHICAL, EMOTIONAL and LOGICAL ELEMENTS of PERSUASION ELEVATES INTERDISCIPLINARY LANGUAGE to INTERDISCIPLINARY COMMUNICATION

The pivotal role that rhetoric elements of ethos, pathos and logos play in viewing the world through Linear-active, Multi-active, and Reactive constructs allows communication underscore to the commonalities and minimize the differences, resulting in the essence of interdisciplinary communication. This model best captures where academic globalization is headed.

CONCLUSION

In conclusion, this paper builds on the model of the Parthenon in suggesting that the LMR framework in conjunction with Aristotle's elements of persuasion- ethos, pathos and logos – serve to highlight unique horizons of the commonalities of communication as follows:



А Multi-Cultural team represents communication beyond with borders. synergistic strengths greater than any sole component of the LMR model. Grounded in the intersection of two trilogies: Linearactive, Multi-active, and Reactive with ethos. pathos and logos, this paper proposes communicating outside of the box, beyond the triangle, where Parthenon pillars interconnect, and language extends beyond cultures to maximize harmonization and foster interdisciplinary communication.

The LMR framework is a powerful facilitator for cross-cultural communication styles. When linked with Aristotle's modes of persuasion, a new dimension is created, which capitalizes upon synchronization and minimizes differentiations to result in a language rich in interdisciplinary communication.

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A missing key stakeholder in curriculum design and development conversations: a brief reflective perspective

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ABSTRACT

Student centeredness is the focus for teaching and learning in institution of higher learning. The learner role has been overlooked in curriculum phases, i.e. planning, design, implementation and review. This paper stresses that the learner role should be strengthened and consistent in curriculum matters. Hence it is argued that a meaningful and robust conversation, around curriculum phases, between course team and students is needed.

INTRODUCTION

Quality education is the central focus from primary school to institution of higher learning. In particular, curriculum design and development has been perceived to play a pivotal role in educational programmes. The focus of this position paper will be on my experience on lecturing practice in the school of engineering at the University of South Africa (Unisa). This also reflects with my interaction with other institutions of higher learning as well as the engineering industry within and outside South Africa. Although the issue of quality education remains debatable [1], the graduate (student) at the completion of a curriculum, is expected to acquire certain skills and competency. The Engineering Council of South Africa (ECSA), which is a professional body, is mandated by the Department of Higher Education of South Africa, to stimulate conversations/discussions on the framework of engineering curricula. ECSA is also mandated for accreditation of engineering programmes in the country. The main focus of the discussions is around the minimum number of

credits for the knowledge areas (e.g. mathematical science. design, engineering science. complementary study, etc) as well as the exit level outcomes of different qualifications within engineering. Academic institutions should comply with minimum credits; however they have the freedom to structure their curricula. The programme is primarily developed for the student or learner who is at the center of teaching and learning. Unfortunately the student, considered as the key stakeholder for teaching and learning is not almost involved in the design process of the curriculum. Hence curricula in my university and other universities within the country and elsewhere are presumably designed by a course team comprised mainly of a group of academics and curricula experts and other units. The course team adopts an instructional design approach (i.e. team approach). In this process, it is rare to associate learners consistently and robustly in discussions on curriculum design and development.

Nonetheless, nearly more than three years ago, the University of South Africa is among the rare institutions in the country which have allowed student representative participation in Learner Support, Tuition and Quality Assurance Committee at college level. This informs the college on issues raised by learners in the learning development stage. The recent revised policy on curriculum at Unisa stipulates that learning development should take into consideration of learners' needs [2]. Efforts have been made at Unisa and other institutions to include important aspects from students' feedback into the review of study material pertaining to a specific module. It is a positive step as far as learning development is concerned. However, what is not yet provided in the team approach at Unisa, in the country and many parts of the world, is the inclusion of a student component in curriculum planning, design, implementation and review. I refer to a consistently active role of the learner in curriculum matters throughout. Hence, the role of the important key stakeholder, i.e. student, needs to be strengthened in institutions of higher learning.

ON THE CURRENT PRACTICE OF TEACHING AND LEARNING

The primitive relationship master to slave for teaching and learning has been characterised by behaviourism [3] and criticised. I will agree to a high degree as some of my students in the past will expect to be spoon-fed rather than going beyond the course material presented. Even when relating to subsequent learning theories such as constructivism [4], connectivism [5], andragogy [6], the active role of the learner hasn't been fully exercised in institutions of higher learning. For instance students are not yet an integral and important part of the curriculum design and development; their contribution to course material (study guide, etc) development is negligible. Very often lecturers accommodate students' needs on pedagogical aspects.

However the debate is not whether learning should be active or passive. The active role of learner is referred to a more participative, hence impactful role. This role goes beyond just active versus passive learning as would be in a face-to-face classroom or a virtual classroom.

The reality is that most students do not even understand curriculum design and development, which remain to some degree a mystery exclusively reserved to a certain group of academics and educational specialists. The situation is also not well understood by most engineering practitioners, who haven't been exposed to teaching activities. Even among us academics, we did not apprehend well the notion of curriculum/programme design and development since we were not exposed to this exercise before we joined our institutions. As far as curriculum review is concerned in most institutions of higher learning, the dominant aspect for academics was to write/review study guides. It is only over accumulated years of experience that I came to understand and became part of curriculum planning, design and development process.

Through the Directorate of Curriculum Design and Development (DCLD), Unisa has provided intensive training to its academic staff in this respect.

Since 2008, the learner role across South Africa is missing in the discussions/conversations on curricula for new engineering programmes at ECSA level. The discussions are mostly dominated by groups of academics and a very minority of engineering practitioners in the industry. These meetings very rarely include non-governmental organisations, and other governmental institutions, private research institutions, etc. The notion of student centeredness as the main focus for curriculum implementation [2] may not be entirely apprehended. The non-consistent inclusion of a student component in curriculum planning, design, implementation and review may not close the gap in the transactional distance between the learner and the lecturer. I am referring here to transactional learning theory according to Moore [7]. Much needs to be done from academics to stimulate this type of conversations as soon as possible. Decades ago, empathy was introduced as a conversational theory learning [8]. I do believe this will contribute to the notion of graduatness at Unisa, e.g. a graduate who is ready to embark on societal issues and contribute to solutions raised from these issues. My understanding is that leadership in higher education should accommodate students to initiate and empower them to participate in curriculum design and development. Otherwise academics will always consider themselves as experts and masters in defining the major components of the curriculum and seemingly reducing students to a slave role.

The current role of the student in curriculum design and development seems to be "behaviourist" where the course team focuses more on instructional design approach rather than a participatory design approach. Students are reduced to a mere reservoir of curricula consumption, rather they should engage robustly and critically in all phases of curriculum.

Engineering curriculum matters, e.g. conversation on new qualifications when needed and syllabus content are discussed in a technical advisory committee. This committee mainly includes mainly academics from the same institution and other institutions and engineering professionals. The conversations/discussions happen at least once a year at Universities of Technology and traditional universities. For the last year meeting at Unisa, specifically civil engineering discipline, we invited two employed students, to come and present on a specific project they have been working on. Although it has been a good experience, the student component is not yet well articulated in this committee, where he/she is supposed to engage meaningfully in discussions.

A holistic approach for teaching and learning may sound an ideal, however, in the current dynamics and complexity, there is a need on a practical aspect for our learners to understand and engage on issues around curriculum design and development.

The current practice in institutions of higher learning suggests that students do not play an impactful role in the planning, design. implementation and review of the curriculum. It is acknowledged that there have been efforts to review study material based on the students' feedback, At Unisa for instance, before the next cycle of material review, comments are some time summarised in a form of a tutorial letter and posted on the learning management system. But more needs to be done, in requesting for example students to give their inputs to the tutorial letter to ascertain whether all issues raised from the sessions been feedback have addressed comprehensively.

ON SUGGESTION OF THE ROLE OF THE STUDENTS FOR CURRICULUM DESIGN AND DEVELOPMENT

The notion of subject matter expert is necessary but sufficient in curriculum not design and development matters. For a long time, the learner active role in the curriculum process hasn't been effective. It is time for academic institutions to make a paradigm shift for curriculum design and development. Students should be invited to informational and conversional session around this matter for serious engagement. In this perspective, the so-called experts may just be facilitators for the curriculum design and development, and not perceived as holy masters. The implication is that the student will be part of the decision making process as far as curriculum issues are concerned.

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Potentiality and limitation of an interdisciplinary work¹

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Abstract: The talks at the "Conversational Participative Session", during The 18th World Multi-Conference on Society, Cybernetics and Informatics: WMSCI 2014, held in Orlando on July 15th, 2014, has motivated this text which describes an experience over multi and interdisciplinary activities, developed in the Department of Geography at Pontifical Catholic University of Minas Gerais - PUC Minas, Belo Horizonte, Brazil. It presents a reflection on the work.

Key words: Spatial Information. Multidisciplinarity. Interdisciplinarity. Society. Mucuri Valley.

INTRODUCTION

The primary goal of Brazilian universities is to integrate the activities of teaching, research and extension. The first task of the Department was selecting a region of Minas Gerais State which could be relevant to the study and where the interaction with local public and/or private administration staff would be possible. It was necessary to create the Laboratory for the Study of Mucuri Valley to host the TOR Project (Teófilo Otoni and its Region) whose main purpose is the study of Teófilo Otoni's influence area, involving Mucuri valley as a whole and its neighborhood, concerning cultural, infrastructure, environmental, socioeconomic, regional and geohistorical features.

The research line on "Geographic Information Systems" welcomes students from different areas of knowledge, ranging from the humanities to the hard sciences, having all masters or doctorate in Geography.

All the students take part in the Lab. Students with master's or doctoral engaged in research receive financial assistance to support their studies. All of them have exemption from tuition fees and some of them receive personal maintenance fees as provided by Brazilian funding agencies CAPES (Coordination of Improvement of Higher Education Personnel), CNPq (National Council for Scientific and Technological Development) and FAPEMIG (Foundation Research Support of the State of Minas Gerais). Moreover, the Pontifical Catholic University of Minas Gerais has its own FIP (Research Incentive Fund). In Mucuri Valley, local leaders often provide accommodation. meals and local transport for students.

¹ Reflexion Text on the subject Interdisciplinary Communication and transferring knowledge to Society at large.

The region consists of twenty-three municipalities, being Teófilo Otoni its main city. It is a multicultural land mainly because its inhabitants are descendants Portuguese, German. French. of Africans, Chinese, Indians and Arabs among others. This mixture of nationalities makes it different from other regions that compose the state. Its soil rich in precious stones moves the local trade. It is rich in food products such as dairy, meat, sugar cane, wheat, and corn starch. Moreover, Teófilo Otoni houses the largest population of Mucuri Valley (140,000 inhabitants) and has the increased commercial interaction among the neighboring municipalities, and those located along the roads crossing it. However, it is one of the poorest regions of the state.

TEACHING, RESEARCH, EXTENSION AND INTERDISCIPLINARITY

It is assumed that Geography refers to both the objects that are distributed in geographic space, and natural, socioeconomic, cultural and technology involved in the production processes of this space. The concepts of space, time, scale and representation, are part of Geography. In addition, Geography seeks to identify the actions of man in society (in space and time) and its impact on various fields of knowledge. It also seeks to recognize similarities and differences.

The recognition of similarities and differences has mathematics and statistics as strong allies of Geography. Furthermore, geographers use computing extensively since it is a very suitable tool for working with large data sets.

The interdisciplinary nature of the work, in addition to Ph.D. students and master's, also includes the participation of professionals from various disciplines with Geography as the core. Since its initial phase in 2006 until the present time, the researches include the dialogue between Geography and at least one of the following disciplines: Architecture, Biology, Cartography, Climatology, Economics, Statistics, Logic. Mathematics. History. Environment, Public Health, Information System, and Sociology

It is known that, during the student's education he (she) should be encouraged master meaningful to knowledge. This favors the approach of theory to practice contributing to their future professional activities. In this sense the disciplines above underlie the triad Teaching, Research and Extension in the implementation of the TOR Project.

These contents are seen in the courses of Master's and Doctoral Program Graduate in Geography - Treatment of Spatial Information or are part of students' prior knowledge.

With knowledge gained from the courses and being aware of the potential and limitations of the region in focus, the students seek to develop their research topics. In sequence fieldwork are performed in order to diagnose problems and create possible solutions.

The research produces dissertations, theses and research papers and, subsequently, the results become available to public and private administrators of the municipalities that comprise the Mucuri Valley.

MAIN RESULTS

The information contained in the databases of the Lab and collected during fieldwork is treated quantitatively, graphically and cartographically with respect to: socio-economic, urban, environmental, infrastructure, regional and geo-historical features.

Events are conducted internally and externally to the Lab. In internal meetings, team members become aware and they interact with all the researches developed. External events were held in the city of Teófilo Otoni to socialize and discuss the results with the local community.

Doctoral dissertations and Master thesis have been produced as well as papers for scientific journals and presentations at conferences. Computer systems have been built to solve spatial analysis problems and maps were produced to facilitate understanding by visualizing the results. Achieved results so far for Teófilo Otoni and its region:

- Hypotheses were generated to feed the new researches
- The scientific literature was strengthened. (with the publication of doctoral dissertations, master thesis, articles, maps ...)
- Options for Action Plans have been proposed for the community and some of them performed by local administrators.

SUBPROJECTS IN PROGRESS

Subjects	Concerned disciplines	
The influence area of the city of Teófilo Otoni *	Geography, Mathematics, GIS	
Pollutants of the Basin Todos os Santos *	Geography, Environment, Biology, GIS	
Applications of Graph Theory to Networking Problems	Mathematics, Geography, Demographics, GIS	
Evolution of Urban Area of Teófilo Otoni *	Geography, Architecture, Demographics, History, GIS	
On the trails of ancient Santa Clara - Philadelphia Road	Geography, History, GIS	
Panorama of drought in the micro region of Teófilo Otoni *	Geography, Environment, Climatology, GIS	

* PhD Dissertation in progress

CHALLENGES

The first challenge is to coordinate a multidisciplinary team. Each member brings in his scientific legacy a way of thinking of their own discipline. And we should seek common ground in interdisciplinary work. This has not been easy. The second challenge: make available to the community the results of research in a language they can understand. It is a work of rewriting the results. In some cases, we still need to be diplomats to convince them of its applicability. The biggest challenge has been how to conduct research in interdisciplinary work. Although having Geography as the core, the exclusive use of its methods is not enough. On the other hand, the disciplines involved follow paths their own of scientific investigation. In a simple way, if we borrowed set theory, perhaps we could characterize the interdisciplinary work as the intersection of two or more disciplines. It would be valid searching a method to consider this intersection?

Even considering the success achieved as an advisor of PhD and Masters Students in conducting interdisciplinary work within a Department of Geography, I believe the question below has not been satisfactorily answered.

What would be the most suitable methods to be employed in interdisciplinary scientific research?

Such methods exist?

ACKNOWLEDGEMENTS

I am grateful to Dr. Magali Maria de Araújo Barroso for her valuable help during the preparation of this text. I would like to thank Dr. João Francisco de Abreu for having read the first draft and suggest improvements.

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The Interdisciplinary Colloquium in Teacher Education*

Esther ZARETSKY

ABSTRACT

A unique inter-disciplinary colloquium on teacher education for lecturers took place in an academic college of education focusing on discussing teacher education in a series of inter-disciplinary meetings and through an on-line forum. Interdisciplinary meetings of this kind rather are unusual.

All the educational department staff members had taught, and were used to teaching, according to the traditional disciplinary method of instruction. Each of the staff members had taught the discipline in which he was an expert. This was so until this paper's author developed a new inter-disciplinary comprehensive educational curriculum including eight books. The new curriculum is based on a methodical and consistent integration of two disciplines or more. The curriculum and the head of the education department at the college suggested to the college administration to organize a curriculum whereby all the college educational staff would learn how to teach according its up-todate original methods. It was recommended to teach it at the college, with the contents to be applied to the specific students' needs. Some of the staff members were required to get approval for teaching using this new method by an established academic institution that used the traditional methods of teaching for general populations.

The research aimed at investigating a new method for teaching staff members how to use the new comprehensive interdisciplinary curriculum and teach according to up-to-date, original methods, and to motivate them to participate successfully and collaborate with each other during the meetings and through the on-line forum.

Both aimed at enhancing the level and quality of teaching at the college by developing knowledge, cognition and communication. Previous studies indicated that lecturers do not know enough about generating and communicating knowledge, especially with regards to the didactics of instilling knowledge.

The method of the colloquium was based on participating in discussion meetings and virtual peer teaching, where lecturers shared their experiences and discussed it.

The findings indicated that the process advanced very rapidly.

The lecturers were able to integrate theory and practice gathered from various interdisciplinary contents.

This clearly affected the lecturers' professional quality up to a level where they were capable of following the rapid pace of learning in the discussion meetings through the e-learning system, and managed the collaborative work as well. The procedure used in this research improved the lecturers' quality of analyzing the interdisciplinary connection between the lectures.

They, especially, increased their ability and motivation for participating in the meetings where the lecturers were selected from among the college staff members. They were surprised to discover that they did not know how much they could get from their colleagues on the college staff without having to search for professional skills outside the college. The learning process was successful apparently thanks to the lecturers' collaborative activities.

The method used in this research enabled the lecturers to activate knowledge in the real world and it was similar to the method implemented in business projects. Cooperating through the computer resulted in peers exchanging knowledge and teaching materials as well.

Keywords: Colloquium, conversation, Communication, Discussion, Inter-Disciplinary, On-line Forum, Teacher Education.

1. INTRODUCTION

The latest studies show that conferences improve knowledge communication of college lecturers (1) (2). Lecturers who participate in academic forums also relate to the integration of theory and practice.

The scientific contribution of the interdisciplinary colloquium focuses mainly on four points:

- 1. Presenting new interdisciplinary ideas and innovations that have not been disseminated in any other way.
- 2. Enhancing professional communication among lecturers.
- 3. Discussing highly important issues.
- 4. Enabling lecturers to contribute and receive new ideas and materials for teachers and student teachers.

2. THEORETICAL REVIEW

"Communication in the sense of cross-fertilization of ideas, involving two or more academic disciplines (such as the disciplines that comprise the cross-disciplinary field of bioethics, including the health and biological sciences the humanities, and the social sciences and law). The communication also includes problems in communication stemming from differences in patterns of language usage in different academic or medical disciplines" (3). "Interdisciplinary communication is mostly human communication, so it could make good use of rhetoric by managing adequate analogies, images, and metaphors in order to be effective" (4). Effective interdisciplinary communication requires meeting certain necessary conditions. Here are some of the most salient: firstly, there must be a dialogue between the lecturers and their students (in our case, the members of the staff).

Usually conferences and colloquiums' presentations are one directional and are mainly managed according to monologic format. Moreover, both kinds of meetings (conferences and colloquiums) focus on one dimension only.

However, Researchers and scholars from different disciplines who communicate via dialogue can learn from each other in fruitful cross-disciplinary interplay and collaboration. The dialogue process enables the lecturers and audience to communicate through analogies, images, and metaphors which are significant in the interdisciplinary communication (5).

the creativity required for The generation of new ideas, hypotheses, innovations, and/or unfamiliar possibilities need creativity by means of interdisciplinary analogies.

Callaos and Horne (4) think that the conversational format might be used, concurrently with conventional conferences' format

^{*}A Successful Attempt at Teaching Novice Computer Users

which focuses on monologic communication, in such a way as to generate synergic relationships between both formats.

To sum up the advantages of interdisciplinary communication let us list the most common among them:

Tradeoff between rigor and adaptability to different disciplines, or multiple rigor versions according to the sought audience plurality, evaluation of original ideas, conversations, dialogues, discussions, argumentations, create knowledge or extend the intellectual common ground, Identification of synergic polar oppositions, assuming different assumptions regarding the meetings' contents and disciplines, shared. to listen to the other side in order to understand, learn, to extend and possibly change a participant's point of view,

The interdisciplinary communication is directed toward analogical thinking and strategic intentional ambiguity, which is required for effective communication versus the Intradisciplinary communication which is supported by logical thinking and informing and it is based mainly on synthetic thinking.

For example, competent readers, lecturers in our case, who are able to integrate knowledge from multiple printed texts may analogically apply their knowledge and strategies for that type of task to integrating ideas in a hypertext environment (6).and use it in the face to face and on-line forum interdisciplinary colloquium' dialogues.

"Instruction that involves systematic, analytic and conscious understandings requires the introduction of an explicit, abstract, conceptual language to describe the underlying structures of meaning" (7). Vigotsky describes the epistemological basis of this process in terms of a shift from the world of complex, analogical thinking (meanings that make sense only because they are situated in experience) to the world of generalizable concepts, transferable from one cultural setting to another" (8) (9). Such a process may enhance the interdisciplinary communication in colloquiums and conferences' meetings. "In the emerging terms of the Designs for Learning project, this involves 'conceptualizing' both in the form of 'naming'' abstract and generalizing concepts and linking concepts in disciplinebased 'theorizing."(7).

Table 1: Examples of Differences between Colloquium'sConversational versus Conventional Formats (4)

	Colloquium's Interdisciplinary Conversational Format	Colloquium's Conventional format
Input	A problem or a question regarding the interdisciplinary curriculum, which will be addressed by a group to all the participants.In the meeting	Paper based on a solution or an answer, which will be presented by an individual (its author).
Output	Sharing of interdisciplinary Knowledge, reflections, ideas and opinions in multi-directional communication	Knowledge or information Communication, Basically unidirectional.
Cybernetic Loops	High levels of feedback cycles in a highly interdisciplinary interactive environment.	None or very low level of feedback in the small time period of questions/answers. 3

	Colloquium's Interdisciplinary Conversational Format	Colloquium's Conventional format
Formal/Infor mal	More informal sharing of ideas and reflections with more possibilities of group creativity and ideas emergence in implementing the new interdisciplinary curriculum in various disciplines and levels	Papers are presented in a formal environment and informal interaction is limited to coffee breaks.
Creativity	Interdisciplinary group creativity in positive loops of feedback.	Individual (or group creativity)
Process	Systemic	Systematic
Implicit General Objective	Oriented to effectiveness in interdisciplinary knowledge communication, sharing of ideas and reflections, solving problems, answering questions, achieving consensual designs, etc.	Oriented to efficient specific disciplinary knowledge or information communication
Whole/Parts	The whole is basically more to the interdisciplinary conversational sum of its parts, such as the new curriculum.	The whole is basically equal (or sometimes even less) to the sum of its parts

In 1999, the U.S. Department of Education established the Preparing Tomorrow's Teachers to Use Technology program in order to support organizational change in teacher education so that future teachers would be able to use interactive information and communication technologies for improving learning and achievement (10). The National Research Council (NRC) in its publication How People Learn: Brain, Mind, Experiences and School (11) argued that "technology resources for education, whether a software science simulation or an interactive reading exercise, function in a social environment, mediated by learning conversations with peers and teachers" (p. 218). The present research deals with interdisciplinary colloquium's face to face conversations and on-line forum among academic college's lecturers.

Montgomery (12) stresses that in the real world of daily scientific work, scientific understanding is an integral part of the written and spoken word. Research involves communicating among a number of central activities, such as: "identifying and studying examples of successful expression in the chosen field" (p. 7).

Harnad (13) indicated that ideas and findings are discussed informally with peers. This is an interactive process that will substantially restructure the pursuit of knowledge.

According to Vigotsky (9), learners actively construct concepts through the process of mediated actions. According to the notion of mediated actions, human beings use cultural tools (such as language as well as tangible features of the environment) which fundamentally change the structure of cognitive functioning and activity (14) (15). Beaufort (16) and Kezar (17) believe that faculty instructors can only be affected by changes such as using

technology in their teaching program if they are actively engaged in creating the change that is taking place. This involvement can be exist by interdisciplinary conversational frequent meetings of the college lecturers and/or school teachers. The notion of Fullan (18) regarding "relationship building" and "shared knowledge" serves as a means for creating shared language and shared responsibility toward technology, a crucial step toward the development of a shared vision about technology in education and a coherent strategy in the school of education for meeting state and national technology standards..

It has been argued that in order to achieve meaningful and lasting educational reform, teachers must collaborate around a strong and commonly held and understood shared sense of purpose (19) (20). This paper will present the application of new interdisciplinary curriculum (21) along with the main objective of the present paper: developing through conversations and online forums regarding teacher education. This research was aimed at advancing this issue.

3. RESEARCH PRESENTATION

The group was composed of 50 lecturers teaching a variety of disciplines in teacher education at the same college. The research focused on the assumption that analyzing the new inter disciplinary curriculum by participation in the colloquium and virtual forums would enhance and raise the lecturers' teaching, instruction level and collaboration between them that in turn would enrich their academic teaching activities. Consequently, they would keep contacts after the colloquium period as well.

Consequently, the lecturers' quality would improve. Initially, the training was designed to last for one year, but actually/ eventually, it continued for more than three years. The main researcher communicated with the participants at least once a week, as needed.

The research report on this colloquium was based on qualitative research composed of conversational meetings and the use of online forums.

The research method

The conversational meetings program focused on interdisciplinary theoretical and practical questions.

Thanks to the use of this method based on instruction via the conversational meetings and the virtual forums, the lecturers became highly motivated and diligent in collaborating with their peers, discussing the issues with the invited lecturers. Following the conversations' organizer and coordinator's (the present paper's author) guidelines, the presenters mostly involved and directly or indirectly engaged the participants during their lectures depending on the contents of the lectures. The colloquium took place in the middle of the academic year. It was based on inviting expert lecturers in their expertise and domain of research and those among the college staff members. In order to avoid overload and alter their personal plans, every meeting included three lectures. The presentations were related to teacher education in order to present relevant topics for the meetings, such as the connection between academic achievements and brain functioning, reading methods for preschoolers, improving pupils' behavior through taking care of animals, etc. Then the participants discussed their application in their teaching at the college.

The teaching procedure and its importance

The on-line forum dealt with enhancing the academic and practical collaboration activity focusing on teacher education. The uniqueness of the on-line forum became clear to the lecturers as they communicated through it. They discussed and consulted each other regarding their own and their peers'**343** academic and practical dilemmas, integrating theoretical and

practical knowledge, and its application by student teachers in their practical work.

The techniques used for fostering virtual interaction between the lecturers were as follows:

- 1. Engaging the contents with their own (the lecturers') real life experiences and implementing this in their practical work with the students.
- Communicating personally, directly and virtually, with each other and with the coordinator, especially for the purpose of guiding them on how to apply the new curriculum in their courses dealing with teacher education.

As a result, the academic communication between the lecturers as a group developed as well. Consequently, the lecturers, guided by the coordinator, accumulated the knowledge and managed it together. Usually, the virtual relationships between the lecturers tended to focus on one discipline. However the method used in this research created interdisciplinary relationships. These relationships also led to interpersonal communication between the lecturers. This type of communication was manifested during and after the colloquium.

Evaluation:

- 1. Comparing the products created by the lecturers.
- 2. Comparing the level of the lecturers' writing via the on-line forum.
- 3. Examining the level of the student teachers' practical work based on the new interdisciplinary curriculum.

4. FINDINGS

The lecturers learned to design and carry out high-level scientific education research. The lecturers also learned to evaluate others' and their own research products. The sources of information included the Internet and the on-line forum. The lecturers used these sources for evaluating the reports by their peers who participated in the same colloquium. The reports of the lecturers became clearer and more detailed as well. The lecturers became aware of the relationships between the pedagogic-didactic achievements and the theoretical scientific approaches they used as the basis of their studies. Furthermore the motivation of the lecturers and their self-confidence were also enhanced. The change in the interaction created between the lecturers took place quickly, especially when considering their lack of experience in using computers before the study.

The lecturers noted that carrying out their research while using the on-line forum and participating in the conference assisted their progress in the project (See Table 2).

	From:	To:
Mode of communication	Starting the colloquium	Intermediate data
Face to face meetings	Starting with monologue	Transferring to dialogue
	The contacts are between the lecturer, coordinator and participants only, with each participant solely.	The contacts occurred also between the lecturer and participants and also among the participants themselves.
	Unaware of analogical thinking	Aware of analogical thinking

Table 2: Example of the gradual transitions from the start to the intermediate stages of the colloquium

Proceedings of The 18th World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI 2014)

Mode of	Starting the	Intermediate data
communication	colloquium	
	-	
On-line forum	Focusing on using	Communicating
	e-mail	through on-line forum
	exclusively.	frequently and
		fluently.
	Contacting in	Contacting while
	general, without	integrating theory and
	using authentic	practice.
	examples.	
	Writing long	Formulating brief
	complex	sentences.
	sentences.	
	Sharing the	Sharing also staff
	messages with the	members.
	lecturer or	
	coordinator only.	
	Unaware of	Aware of analogical
	analogical	thinking.
	thinking.	

5. DISCUSSION

The question raised in this research was "how can face-to-face and virtual colloquium improve academic conversational meetings and the inter-disciplinary teaching by the college staff? "

The on-line forum enabled the lecturers to communicate at any time and place in the world with anyone who belonged to the stuff. All the staff members who registered in the specific forum's on-line site could access the unique program group's website of the academic institution. The uniqueness of the colloquium studied in this research is manifested by its interdisciplinary characteristics such as the new curriculum focusing on education and science, psychology, etc. In addition, the staff members came from a variety of disciplines. In contrast to conventional meetings, the conversational meetings also enabled discussions regarding the integration of theory and practice in various disciplines. Callaos and Horne (4) suggested integrating dialogical conversations with monolingual conventional meetings in conferences (22) (23) (24).

6. SUMMARY AND CONCLUSIONS

The present study showed that communicating academically among the lecturers through the interdisciplinary direct and virtual colloquium fostered theoretical and practical collaboration.

The results also indicated that the lecturers increased their theoretical knowledge (25) (26), and applied the best research methods in each one of the disciplines. The scientific importance of the colloquium lay the lecturers' increased ability to collaborate and exploit their theoretical knowledge and practical experiences, and express it in high-level academic presentation and writing through the on-line forum (22) (23) (27) (28) (29). The collaboration in sharing theories and teaching methods among the lecturers in the present research created social interaction between them, which is necessary for their student teachers' accommodating "real life" problems that appear in the real world of daily scientific work (12). Consequently, basing the face to face and on-line forum dialogues among the lecturers on real life activities affected the educational environments of their student teachers. This resulted in improving academic communication during the courses, while the lecturers themselves would apply the method used in the interdisciplinary 344 colloquium.

This effective method of using interdisciplinary conversational format development concurrently with the conventional format should be implemented in future face to face and virtual conferences and colloquiums.

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Academic Ethos, Pathos, and Logos

RESEARCH ETHOS

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ABSTRACT

Elsewhere (N. Callaos and B. Callaos, 2014)¹ we have shown the conceptual necessity and the pragmatic importance of including Ethos, Pathos, and Logos in any methodology for Information Systems systemic Development (including software-based systems) and for the design and implementation of informing processes. This is the first article of a planned series in which we will try to apply what has been shown and concluded in the mentioned article to the specific case of Academic Informing or Academic Information Systems. Research activities include informing processes, which should address the respective Ethos. Our purpose in this article is to address one of the issues involved in this aspect. With this article we are trying to make a step forward according to the recommendations we included in the conclusions of the referred article (N. Callaos and B. Callaos, 2014). To do so, we will briefly abridge previous work, provide some facts via real life examples, give few opinions and ask many questions. Few of these questions will be rhetorical one while most of them are oriented to generate reflections in the respective issue and potentially some research, intellectual enquiry, or practice based position papers.

GENERAL CONTEXT

It is evident that effective communication is a necessary condition for Academic Informing. This effectiveness has been basically related to academic writing, pedagogical innovations, and educational technologies, mostly in the context of disciplinary logic and rigor. Persuasiveness in academic writing has been admitted for a long time as necessary condition for effective academic communication and informing. That academic writing is, or should be, *persuasive* is not news. Ken Hyland affirms that "It dates back at least as far Aristotle and *it is widely* accepted by academics themselves."² This includes scientific communication. An increasing number of articles and books have been published lately regarding importance of persuasiveness in scientific the communications and on the Rhetoric of Science.³ But, the focus has been, up to the present, on academic writing. Our academic and professional experience show that persuasiveness is, or should be, implicitly or explicitly, an essential characteristic in all academic activities: research, education, and consulting or problem solving, and not just in academic writing. Experience-based reflections show that a more comprehensive and systemic approach is required for enhancing the effectiveness of Academic Informing in its societal and civic contexts. A main purpose of the articles series, mentioned above, is to examine and reflect on a more comprehensive approach to Academic Informing for a higher effectiveness of these activities. This will be attempted from a pragmaticteleological perspective, i.e. oriented by the ends of Academic Informing and by the potential means that might be used to achieve these ends. We will focus in applying classical means which have effectively been applied in the past but they are not being applied (at least not explicitly) in the last few decades to support academic informing. Consequently, we will examine the relationships between academic activities and persuasive processes or methodologies, focusing mostly on Academic Ethos, Pathos, and Logos, as fundamental and necessary characteristics of more persuasive academic informing and, hence, more effective academic activities.

SPECIFIC CONTEXT

A main source of the mentioned series of articles, and of this first one, will be our about 45 years of academic and professional activities. This will be a main input to applying a mostly *Reflexive Methodology*,⁴ regarding the issue described above. Part of this practice-based

¹ This article is based on previous articles and on practice-based reflections as well as on Action-Research and Action-Learning in the context Methodological Action-Design.

² Italics added

³ See for example Alan G. Gross, 1996, 2006, and H. W. Simon (Ed.), 1990.

⁴ See for, example, M. Alvesson and K. Sköldberg, 2001, 2009; and K. Etherington, 2004.

reflections and conclusions was the article mentioned above which mostly represent a product of our professional experience in the context of Information Systems and Informing Processes analysis, design, and implementation.

In the mentioned article, we basically applied what Donald Schön (1983) proposed, in "The "*Reflective Practitioner*" in the context of our professional Practice. Now we will try to apply it in the context of our academic activities. Our aim in this paper is to make a short presentation of the main reflections and conclusions we have had during our academic practice in researchoriented informing activities (including peer review, conferences organization, journal editing, research administration, etc.). Educations and consulting will be addressed in following articles, and mentioned in this article when they have relationships with the main topic here.

INTELLECTUAL AND PRAGMATIC IMPORTANCE OF ACADEMIC ETHOS, PATHOS, AND LOGOS

In this section we will address the intellectual and pragmatic importance of Academic Ethos, Pathos, and Logos. Next articles will go in more details regarding this issue. Let us her provide a very brief discussion on this issue which objective is to provide Intellectual and Pragmatic context for following sections.

We have been for a long time explicitly and frequently emphasizing in our classes, to our students and colleagues, in both Higher Education and Industrial contexts, that the very well known Medieval Trivium is not being adequately applied Higher Education⁵, or not applied at all in some Higher Education organizations. We noticed this educational gap while teaching Information Systems (to students in Computer Engineering) and practicing in the area of Information Systems Engineering, for about 35 years simultaneously in both cases. We have discussed at length (including conferences presentations and publications⁶) during these 35 years that Computing and Software Engineering are necessary conditions for the development of computingbased information systems, tailored to the specific needs and requirements of a specific organization or suborganization. But, they certainly are not sufficient conditions for the professional effectiveness in developing this kind of information systems. Computer or software engineers need to adequately communicate with

machines, but they also need to have the skills for effective communication with human beings (the users) for adequately eliciting the respective requirements, designing an adequate system, training the users for an effective use of the system, and maintaining the system especially when new requirements emerge as a consequence of the dynamics, uncertainties, and changes in which the organizations are always immersed in. This means that the system analyst/synthesist needs to communicate with both computers via artificial languages and the users via natural languages. He/She also need to make adequate translation between both languages. Otherwise, there will be a high probability of failure no matter how good he/she is as computer or software engineer or computer scientist. Skills in natural languages and effective communication are what the Medieval Trivium is about. This is why we included a detailed exploration regarding this issue in our detailed work regarding a "Systemic Systems Methodology" (N. Callaos, 1995) which might contain local systematic parts but it is a systemic one as a hole.

As a communicational process, academic informing effectiveness depends, at least, on the adequacy of the communicational means used; which, in turn, depends on the comprehensiveness of the possible/feasible means, as well as on the potential synergies and emergent properties that might be generated in their simultaneous design and implementation. In order the increase the probability of being comprehensive, it might be advisable to explore the product of many years of reflection regarding the essence of human communication and the means suggested as necessary for its effectiveness. Our experience shows us that the classical means are far from being obsoletes, though they require being adapted to the present objectives of academic informing as well as to the new communicational technologies, tools, and methodologies.

Beside *comprehensiveness*, a systemic approach would require an adequate *contextualization* of what is being examined. Since Academic Informing is an essential part of academic activities, it should be examined from the perspective of its general context of academic activities which include academic thinking, academic behaving, academic caring, academic valuing, etc. besides academic informing. Consequently, we will be referring mostly to academic activities and in some specific situations to academic informing and to the relationships that exist, or should exist, between academic informing and other academic activities.

NINE AREAS THAT SHOULD BE ADDRESSED

With regard to a comprehensive study, we suggest that the traditional triad of Ethos (character, integrity, credibility), Pathos (emotion, feelings), and Logos (logic, language) are applicable and/or are being (implicitly or explicitly) applied and/or should be applied in academic

⁵ See, for example, Callaos N. and Callaos B., 2014, pp. 21-25; and N. Callaos, 1995, pp. 527-534 for the case of Systems Engineering and Computing Engineering.

⁶ In Callaos and Callaos, 2014, we integrated and resumed what we presented in many conferences, written in many publications, and emphasized in many academic and industrial courses.

activities each of the three main academic activities: research, education, and consulting or real life problem solving. Each one of these three academic activities requires:

- A. Convincing by means of the *character*, *integrity*, *and credibility* of the academic as author, educator and/or consultant.
- B. Persuading colleagues, students, and/or clients by also appealing to *emotions* of both the communicating academic and receiver of the message intended to be communicated.
- C. Persuading colleagues, students, and/or clients by the use of *reasoning*, *logical arguments*, and an effective use of the communication languages (technical an natural) being used

This might be framed in the context of a 3x3 matrix, i.e. Ethos, Pathos, and Logos as related to each of the three basic academic activities, i.e. Research, Education, and Consulting or Real Life Problem Solving. With this framework we can relate/integrate the three academic activities and the three persuading means, among each other and between activities and means. Consequently, nine specific areas should be addressed. If we add to these areas the relationships among them and the second level of *Meta-Ethics, Meta-Pathos*, and *Meta-Logos*, then we can notice that there are many analytical areas that might be addressed in a comprehensive analysis. This is why we are thinking about a series of articles; which, as a set, might address the most important aspects of this issue.

On the other hand, if we accept that, 1) the three academic activities should be *integrated* for the potential generation of synergies and beneficial emergent properties, and 2) the classical triad of Ethos, Pathos, and Logos are related to each other⁷ and integrated in human intellectual activities, then it is easy to imagine that all 9 kinds (matrix 3x3) of academic ends/means would be, or should be thought as, integrated in a synergic whole, which synergy would be greater than integrating academic activities according to just one of triadic elements of Ethos, Pathos, and Logos.

Having provided a brief description of the general context, the specific context, and a an initial analysis, which should precede to a necessary integration of the parts produced by the analysis, our purpose in what follows is to focus in one very important (we would say vital) aspect of Research Ethos (i.e. one of the nine fundamental issues presented above); while pointing to the relationships it has (or might have) with the other analytical ingredients mentioned above.

RESEARCH ETHOS

An important, probably a *necessary condition* in research activities is to adequately communicate the results of these activities. Consequently, Ethos, Pathos, and Logos are required for this kind of communication. Even so, an increasing number of research communication are lacking of the respective Ethos, Pathos, or Logos. Many scientific or engineering communications lack even the three of them. Let us present some recent (and less recent) much known examples.

The International Weekly Journal of Science Nature 1. reported on February 25th, 2014 that "Publishers withdraw more than 120 gibberish papers." Richard Van Noorden⁸ (2014) affirmed that "Conference proceedings removed from subscription databases after scientist reveals that they were computergenerated...The publishers Springer and IEEE are removing more than 120 papers from their subscription services after a French researcher discovered that the works were computer-generated nonsense... Ruth Francis, UK head of communications at Springer, says that the company has contacted editors, and is trying to contact authors, about the issues surrounding the articles that are coming down. The relevant conference proceedings were peer reviewed, she confirms making it more mystifying that the papers were accepted."

Consequently, many questions arise:

• Did the Publishers have Scientific Misconduct or Unethical Behavior? No, they did not, in our opinion. Publishers like IEEE and Elsevier would not do it because it makes no sense at all. The amount of money involved is extremely negligible as compared with their annual revenue and they would never risk their prestigious image and high credibility level. This is just a pragmatic reasoning. There are many other reasons, especially related to their history and the great service they provided, for a long time, to be credible channels for

⁷ In N. Callaos and B. Callaos, 2014 we have shown that the relationships among Ethos, Pathos, and Logos are actually, or potentially might be, of a cybernetic nature, including potential co-regulative loops (via reciprocal negative feedback and feedforward) and co-amplificatory loops (via reciprocal positive feedback)

⁸ Richard Van Noorden "has reported for *Nature* in London since 2009, after spending two years as a reporter at *Chemistry World*. He has a master's degree in natural sciences from the University of Cambridge." (*Nature*, doi:10.1038/nature.2014.14763)
scientific communications via publications of papers.

- Did the respective Editor-in-Chief have Scientific Misconduct or Unethical Behavior? Not necessarily, in our opinion, because for similar reasons, it would make no sense.
- *The conference Organizers?* Not necessarily in our opinion, because reputable journals with high scientific prestige and reputable editors also had the same kind of ethical problems, and pragmatic concerns. We will present one example later.
- *The authors?* In this specific case, our opinion is an almost a certainty that authors have had unethical behavior and academic or scientific misconduct. But, authors has not always had this kind of misconduct because there have been several intentional hoaxes that have been submitted in order to announce them later. We will see some of these cases below.
- The reviewers of these papers? The Peer Reviewing Methodology Applied? Very probably in our opinion and according to our experience, this is the case. In a survey of members of the Scientific Research Society "only 8% agreed that 'peer review work well as it is'." (Chubin and Hackett, 1990, p. 192) Is the essence of the scientific publications quality assurance highly ineffective? Is the whole academic promotional system based on something that just the 8% think is working? Is it ethical to continue "measuring" the research performance of academic with a toll that just the 8% believe it is effective? Is this ethical? How many scholars are really concerned about this issue? Is there any consensus about what the notion of "peer" means? How many concerned scholars, conference organizers, editors, or publishers are trying to find a solution to this paradoxical problem?

While one of the authors of this article was Dean of Research and Development of a university, we had the experience of trying to identify, during two years, a consensual meaning, or definition, of an internal "peer" in the university, and it was not possible. The more we tried to generate a consensus regarding this issue, among the university's professors, the more controversial became what the term means or should mean. Paradoxically, in the same university, external "peer" generated an immediate consensus, i.e. the (unknown) peers of a "prestigious" journal, and the level of prestige of the journal was associated with its impact factor. Isn't paradoxical that there was no way to define a "peer" associated to the professors of the university, but it was "evident" who are peers, as long as they were professors from other universities, who are unknown and selected by unknown editors. Later, we found out, after a literature search, that the notions related to these terms have not been sufficiently addressed. We tried to find in the literature short description of the meaning of "peer" and "peer reviewing" in order to elicit from scholars some intellectual feedback, but the attempt was unsuccessful. Consequently, we proceeded to write very short descriptions of the notion of "peer" and "peer reviewing" (Callaos, 2005). Our intention in keeping these descriptions short ones was (and still is) to ask for small amount of time from the reader in order to increase the readership potential and, hence, the probability of generating comments as well as awareness regarding this issue

- Is anyone else, implicitly and/or unknowingly, is having ethical issues, beside those mentioned above? Should some chairs of academic departments consider the Academic Ethos (and probably the Pathos and Logos) related to the fact that only 8% of the members of the Scientific Research Society agreed that 'peer review work well as it is'? Should they try to identify a consensus among the professors of their departments regarding the meaning of "peer" and/or "peer review"? In such a case should they publish these meanings in order to clarify it to the faculty members of their department? Should they continue delegating the ingredients of their decisions regarding the promotions of their faculties in the hand of unknown reviewers selected by not necessarily well known editors?
- On July 13, 2014, in an op-ed of the Wall Street Journal, Hank Campbell (2014), founder of Science 2:0 web site, in an article titled "The Corruption of Peer Review Is Harming Scientific Credibility," informed that the reputable SAGE Publications retracted 60 articles implicated in a peer review ring

at the Journal of Vibration and Control. This peer review ring involved assumed and fabricated identities which were used to manipulate the online SAGE submission and reviewing system. Previously The Guardian reported this news with the title "Academic journal retracts articles over 'peer review ring' with bogus scholars." (Jon Swaine, 2014) Steven T. Physics Today reported this fact, on July 11, 2014, with the title "Peer-review fraud cited in retraction of 60 academic papers." Corneliussen (2014), a media analyst for the American Institute of *Physics*, referring on other publications, affirms that "the penalties for scientific fraud are generally insufficient, with too little repayment of misused funding, with too little professional ostracism of offenders, and with resignations forced-and criminal charges filed-too rarely." This means (in our opinion) that *meta-ethical* issues have to be considered besides the ethical ones; i.e. peer reviewing methodologies should have to include ways, methods (a systemic methodology?⁹) of enforcing ethical behavior in science, and the Scientific Enterprise should also include stronger and more explicit rules and policies with regards to scientific misconduct and unethical behavior; i.e. it should be more involved and concerned at the metaethical level. In a recent comprehensive study DuBois, Anderson, and Chibnall (2013), with the aim of determining the frequency and kinds of wrongdoing at *leading research institutions*¹⁰ in the United States," concluded with the following terms:

"Wrongdoing in research is relatively common with nearly all research-intensive institutions confronting cases over the past 2 years. Only 13% of respondents indicated that a case involved termination, despite the fact that more than 50% of the cases reported by RIOs [research integrity officers] involved FFP [falsification, fabrication, or plagiarism]. This means that *most investigators who engage in wrongdoing, even serious wrongdoing, continue to conduct research at their institutions*."¹¹

This clearly shows that even leading research institutions are requiring addressing both the metaethical and ethical levels in research. Actually, in our opinion, the academic promotional policies are contributing in the generation of unethical activities in both research and education. An academic who is unethical in the publications of his/her research the more unethical might be in his/her activities in education. In this case there are at least two generating causes of academic misconduct: a) a promotional system oriented to research production that frequently undermines the educational activities of the academic, and 2) educational misconduct is usually less visible than research publications.

Consequently, it seems evident that the Scientific Enterprise and specially leading research institutions (especially leading research universities), should urgently and carefully review both the ethical and the meta-ethical issues related to research, education, and consulting. In our opinion, the Academic Ethos should be examined not in isolation, but along with 1) its relations with the Academic Pathos, i.e. the kind of emotions which generation should be addressed and promoted in order to increase the probability of ethical behavior and 2) its metaethical rules, policies, enforcement, and behavior. To have a promotional system based essentially (and sometimes exclusively) in research production *metrics* (number of publications, citation index, journal impact, etc.) may be making more harm than good. Metrics are *means*, and as such should never be confused with the ends or (which is worst) taken as ends in themselves. The later is one of the powerful sources of corruption, including both the conscious and the unconscious ones. An academic department chair should not reduce his chairmanship activities to an accounting exercise based on metrics produced by other institutions which, in turn, are based on other metrics used by yet other organizations and the processes leading to these metrics are based on unknown peer-reviewers chosen according the traditional double-blind reviewing methodologies. Why Ph. D. dissertations have explicitly known reviewers (the Ph. D. committee's members) who sign the respective thesis while just anonymous reviewers are who recommend to accept or to refuse the publication of a given article? Shouldn't peer reviewing methodologies be based on non-anonymous reviewers or on both anonymous (double-blind) and non-anonymous reviewers? In trying to answer this question we proposed, and have been working with (since 2006) a two-tier reviewing methodology which include both anonymous (double-blind) and non-anonymous reviewers. In our methodology, both reviewing processes should end up recommending the acceptance of a paper in order to generate and editorial decision regarding the acceptance of the article for its publication as a peer-reviewed article. Publication recommendation in each tier is a necessary condition but not a sufficient one for acceptance for presentation and/or publication. Recommendations from both tiers are required. We think that with this methodology we are making an initial step in addressing the meta-ethical level of the reviewing/publication processes. More details (but in a short description) can be found at (Callaos,

⁹ Se for example (Callaos and Callaos, 2014)

¹⁰ Italics and emphasis added.

¹¹ Italics and emphasis added.

2006). More details in a larger article can be found at (Callaos, 2011)

- On April 11, 2012 Carl Zimmer, in an article in the 3. New Work Time, entitled "A Sharp Rise in Retractions Prompts Calls for Reform" addressed the issue of the exponentially increasing number of retractions in scientific journals in the last 10 *vears*. Zimmer based his article on an unsettling discovery made by Dr. Fang, who is editor in chief of the journal Infection and Immunity regarding the increasing number of retractions. Simmer reports that Dr. Fang, who is a professor at the University of Washington School of Medicine, affirmed regarding the increasing number of retractions that "[n]o body had noticed the whole thing was rotten ... a symptom of a dysfunctional scientific climate." Zimmer reports that Dr. Fang looked, with a fellow editor at the journal, Dr. Arturo Casadevall, "at the rate of retractions in 17 journals from 2001 to 2010 and compared it with the journals' 'impact factor,' a score based on how often their papers are cited by scientists. The higher a journal's impact factor, the two editors found, the higher its retraction rate."¹² Consequently, if we were to measure the quality of a journal by the number of retractions has had, the journal with high impact (which articles are the most cited) would have lesser quality than those journals with lower impact. Does that make any sense? Should the quality of a journal be measured just with its impact factor? Should the impact factor be defined just as the number of average citations per article? Should there be other accepted definitions or metrics of journals' quality or "impact factor"? Isn't an ethical issue to answer, or at least to try to answer, this kind of questions?
- The most preoccupying aspect of the retraction rate 4. is its explosive increase in the last 10 years. Richard Van Noorden (2011) reports, in an article published by Nature (International Weekly Journal of Science), that "In the past decade, the number of retraction notices has shot up 10-fold [1000%], even as the literature has expanded by only 44%." The exponential growth is shown in the figure included in the Van Noorden's (2011) article, as well as in figure 1a of Brembs et al.'s (2013) article entitled "Deep impact: unintended consequences of journal rank." Brembs et al. (2013) also shows (in figure 1D of their article) the exponential relationships between the retraction index and the impact factor of the retracting journal: the more the impact factor, the exponentially more the retracting index. Consequently, among their conclusions, Brembs et al. (2013) conclude that

"There are thus several converging lines of evidence which indicate that publications in high ranking journals are not only more likely to be fraudulent than articles in lower ranking journals, but also more likely to present discoveries which are less reliable (i.e., are inflated, or cannot subsequently be replicated). Some of the sociological mechanisms behind these correlations have been documented, such as pressure to publish (preferably positive results in high-ranking journals), leading to the potential for *decreased ethical standards*.¹³ (Anderson et al., 2007)"

Shi V. Liu (2006) showed that "the percentage of retraction of the above four top journals among all retractions are on the rising trend, from 1.42% in the 1980s to 6.96% in the 1990s and to 9.18% in the first 6 years of 2000s" Based on a search in PubMed on May 6, 2006, Liu (2006) listed 47 journals. The top of them according to their respective impact factors (Science, Nature, PNAS, and Cell) had 38, 32, 32, and 13 retractions respectively. All 47 journals had 309 retractions. This means that the 0.085% of the journals (the top four) had the 37.22% of all retractions. This is astonishing! 0.085% of the journals (the ones with the highest impact factors) are generating the 37.22% of the retractions.

Liu (2006) resumed his article, published in *Scientific Ethics* 1(2), pp. 91-93, in the abstract as follows:

"Top journals often use the highly exaggerated and even flawed values of the impact factors to boost their circulations among readers and increase their attractions to authors. This commercial strategy apparently worked very well because many scientific administrators have now used the place (journals) of publication as a criterion for evaluating the value of the publication. However, from a and objective perspective, top historical journals' high-profile publications often stand low in comparing with those truly groundbreaking and thus not "trendy" papers in the then "cold" or even ignored fields. More ironically, many such truly great papers were initially rejected by the top journals. In contrast, many "hot" and "trendy" papers published by top journals actually ended up with "spectacular" retractions. Thus, while top journals emphasize their impact factors they should realize that their impacts are doublesided. They should also confess to the world that they are also the world leaders in publishing retractions." (Liu, 2006, p. 91)

¹³ Italics and emphasis added.

¹² Italics and emphasis added.

Peter A. Lawrence (2008) resumes his paper entitled "Lost in publication: how measurement harms science"

"Measurement of scientific productivity is difficult. The measures used (impact factor of the journal, citations to the paper being measured) are crude. But these measures are now so universally adopted that they determine that things matter: tenure most or unemployment, a postdoctoral grant or none, success or failure. As a result, scientists have been forced to downgrade their primary aim from making discoveries to publishing as many papers as possible—and trying to work them into high impact factor journals. Consequently, scientific behaviour has become distorted and the utility, quality and objectivity of articles have deteriorated. Changes to the way scientists are assessed are urgently needed, and I suggest some here."¹⁴ (Lawrence, 2008, Abstract, p. 9)

The two abstract mentioned above are just examples of an increasing number of articles in which researchers, scholars, and editors are increasingly questioning the validity of the metrics being used, as unique indicators of the quality of academic articles. Is it ethical to continue using metrics that increase the probability of unethical behavior in scientific research? Is it ethical to use metrics that are distorting scientific behavior? Is it ethical to force scientists "to downgrade their primary aim from making discoveries to publishing as many papers as possible"? Doesn't this distortion represent intellectual and/or academic corruption? Shouldn't we (at least try to) identify other ways of evaluating the quality of scientific publications? Isn't that an ethical, or meta-ethical, requirement? An increasing scientists, number of editors, academic administrators, and science managers (e.g. Brembs et al., 2013; Anderson et al., 2007) are at least trying to find ways of assessing scientific quality where established means and metrics are not being taken as end in itself. More research is required in this area if we are going to at least try to address both the ethical and the meta-ethical levels of scientific or scholarly research.

5. In June 15, 2009 the academics and scientists were disconcerted when they learned about a reputable journal accepting (after reviewing) and publishing an article which content was randomly generated. Nature published the news with the title "*Editor will quit over hoax paper: Computer-generated manuscript accepted for publication in open-access journal*." In this article, Natasha Gilbert (2009) reports that "[t]he fake, computer-generated

manuscript was submitted to The Open Information Science Journal [Bentham Science Publishing] by Philip Davis, a graduate student in communication sciences at Cornell University in Ithaca, New York, and Kent Anderson, executive director of international business and product development at The New England Journal of Medicine. They produced the paper using software that generates grammatically correct but nonsensical text, and submitted the manuscript under pseudonyms." Bambang Parmanto, who is an information scientist at the University of Pittsburgh, Pennsylvania, and was the editor-in-chief of The Open Information Science Journal, declared to Nature (according to Gilbert, 2009) "I think this is a breach of policy ... I will definitely resign. Normally I see everything that comes through. I don't know why I did not see this. I at least need to see the reviewer's comments." Parmanto claims that the Bentham published the article without his knowledge, and the director of publications at Bentham Science Publishing defended Bentham's peer review process, saying (according to Gilbert, 2009), "a rigorous peer review process takes place for all articles that are submitted to us for publication. Our standard policy is that at least two positive comments are required from the referees before an article is accepted for publication." In this particular case, "the paper was reviewed by more than one person". In our opinion, this is another example of traditional peer reviewing failure. What is astonishing is that for several decades many editors, authors, and studies concluded that the traditional double-blind peer review's failures are overwhelming¹⁵, but not much has been done 1) to substitute it by other methods for quality assessment of scientific research articles, or at least 2) to improve it via complementing it with other reviewing methods. This is a really perplexing issue. Traditional peer review is abysmally failing and the Scientific Enterprise is still based on it. Traditional peer review is astonishingly ineffective and (as we said above) only 8% of Scientific Research Society's agreed that 'peer review work well as it is', (Chubin and Hackett, 1990, p. 192). It is ineffective and it is perceived as ineffective by scientists but it is still untouched and untouchable by the academic world. Is it an Academic Totem?

¹⁴ Italics and emphasis added.

¹⁵ We reported on many of these conclusions made by editors, authors, and specific studies regarding the ineffectiveness of traditional peer review in Callaos, 2011, *Peer Reviewing: Weaknesses and Proposed Solutions* at

https://www.academia.edu/4437207/Peer_Reviewing_W eaknesses_and_Proposed_Solutions

Is it ethical for academics, scientists, researchers, engineers, professionals, academic administrators, etc. to continue ignoring this perplexing issue? Is it ethical to force the new generations of scientists and academics to accept that their career depends on a clearly failed quality assessment tools for valuing the merit of their research? Is it ethical not to, at least, ask these questions? Is it ethical not to, at least, <u>try</u> to solve this paradoxical situation or to ameliorate its effect while a solution is identified?

6. Even reputable journals with high prestige and high impact factor that charge readers for their content (via subscriptions) may be prone to accepting nonsense and gibberish papers which are randomly computer-generated. Peter Aldhous (2007), for example, reported in New Scientist (owned by the publishing giant Reed-Elsevier) that graduate students at Sharif University in Iran got a randomly computer-generated paper accepted by "Applied Mathematics and Computation," which is a journal with a very high reputation published by Elsevier (part of Reed-Elsevier, the publishing giant that owns New Scientist in which this news was also reported). Aldhous (2007) reports that "[a]fter the spoof was revealed, the pre-publication version of the paper was removed from Elsevier's Science Direct website." The proof-correcting queries sent to the hoaxers by Elsevier can be found at http://pdos.csail.mit.edu/scigen/sharif query.pdf.

The removal of the paper after being published is at <u>www.sciencedirect.com/science/article/pii/S0096300</u> <u>307003359</u>. Aldhous (2007), also reports that "Melvin Scott, a retired mathematician based in Ocean Isle Beach, North Carolina, who serves as editor-in-chief of *Applied Mathematics and Computation*, says that the paper was accepted by an editor who has since left the journal. "I've revamped the editorial board significantly," he adds.

It is evident, in our opinion, that the publisher did not have an unethical behavior. It is also highly probable that the editor-in-chief did not have unethical behavior either. Very probably it was the editor and/or the reviewers of the paper who behaved unethically. It is also very probably that the reviewing methodology failed in its scientific quality assessment, especially because it very probably did not include the <u>meta-ethical dimension</u>, i.e. 1) a procedure or a method for the identification unethical behavior from the authors, the reviewers and/or the editors, or 2) a methodological ingredient for <u>enforcing ethical behavior</u>, or for minimizing the probability of scientific misconduct.

7. Another example, which shows other aspects of the problem at hand, the acceptance of an article we did for WMSCI 2005. This article was accepted for

presentation as a non-reviewed¹⁶ one and its acceptance was based on the CVs of the authors. The acceptance letter clearly said so, and the authors were informed that the paper might be accepted later as a *reviewed* one as soon as its reviewing process is finished. The conference's web site said clearly that about 15% of the submitted articles might be accepted as non-reviewed. The related article happened to be a randomly computer-generated one. This news was published in many outlets without informing about the whole truth, i.e. the article was accepted as a non-reviewed one and the conference web site informed up-front that about 15% of the articles will be accepted as non-reviewed. Is it ethical to present part of the truth and to take it completely out of its context? Many well intentioned academics repeated what they read in the web without any confirmation of what they read and what they are saying. Is this academically ethical? The WMSCI 2005 web page (saved in Web.Archive at http://web.archive.org/web/20070209005022/http:// www.iiisci.org/sci2005/website/Papers acceptance.a sp) informed very clearly the following:

Acceptance decisions related to the submitted papers will be based on their respective content review and/or on the respective author's CV. Invited papers will not be reviewed and their acceptance decision will be based on the topic and the respective author's CV.

If the reviewers selected for reviewing a given paper do not make their respective reviews before the papers acceptance deadline, the selection committee may accept the paper as a non-reviewed paper.

If a paper does not meet the criteria for inclusion as reviewed paper, the selection committee may invite the author to present it as a non-reviewed paper.

Each accepted paper (reviewed and non-reviewed) is candidate for being a best paper of its respective session and, consequently, it is candidate for a second reviewing process to be made by the reviewers of the Journal Of Systemics, Cybernetics and Informatics (JSCI), by means of which the best 10%-20% of the papers presented at the conference will be selected and published in the JSCI after doing possible modifications (in content/format) and extensions as to adequate them to a journal publication.

Many academics rushed to judgment before reading this text and continued with a false narrative based on part of the truth and taken completely out of its context. Is that academically ethical? Journalistically it is not ethical and journalists stopped the story after interviewed us and after reading the text above. Shouldn't academics follow journalists ethics when

¹⁶ A copy of the acceptance letter sent to the corresponding author is shown as Appendix B of the document at

http://iiis.org/contents/With_Regards_to_the_bogus_pape rs_submitted_to_WMSCI2005_%28Ed.%29_31-5-2014.pdf

making citizenship journalism via blogs, email lists, etc.?

According to WMSCI 2005 published acceptance policy, the article was accepted for presentation as a non-reviewed one and because of the previous publications of its authors (the MIT's Ph. D. students). The reasons supporting this acceptance policy have been explained with details elsewhere (Callaos, 2014; pp. 7-10). These reasons are valid in some disciplines and not valid in other disciplines. There are reputable conferences with no peer-review at all. Examples can be found in the meetings of the American Mathematical Society: AMS, The Southeastern International Conference on Combinatorics, Graph Theory, and Computing, etc. (http://blog.computationalcomplexity.org/2007/11/un refereed-does-not-equal-bogus.html).

Another example is found in the prestigious, large, and very known INFORMS/IFORS conferences, of the Institute for Operations Research and the Management Sciences (INFORMS) and the International Federation of Operations Research Societies (IFORS), which we attended several times. They announce clearly and explicitly that "<u>Contributed abstracts are not reviewed and</u> <u>virtually all abstracts are accepted.</u>"¹⁷

Different disciplines have different conceptions regarding this issue. Then, <u>what should a</u> <u>multidisciplinary conference do with this regard?</u> Being WMSCI a multi-disciplinary conference we tried to apply a multi-modal acceptance policy in which the presentation of reviewed papers are combined the presentation of a small number of non-reviewed ones, but all those that would be published in the journal are or will be reviewed, some of them twice or three times.

ETHICAL ISSUES REGARDING WMSCI 2005 CASE

How many academics read this text above which was explicitly and clearly posted in WMSCI 2005 web site and respective call for papers? How many did so before rushing to judgment? Is it acceptable to judge a conference in a given discipline according the standards of other discipline? Is it ethical to smear a whole conference repeating half truths completely taken out of their context? Should this kind of academics provide education to our kids? What is the difference between this kinds of academics and the scientists who select what data from his/her observations to present and what not to present (or to hide) in order to confirm his/her hypothesis or pre-judgments? Should scientific ethics be followed just in the context of scientific activities while choosing not to follow it when judging activities of other academics? Isn't perplexing that reputable academics, with the very good intention of protecting Science from misbehavior, misbehave when judging other academic activities? Do these scholars have consciousness or awareness about the unethical behavior they are having while their intention is to do the right things of protecting Science from those who abuse it?

As we asked above, should scientists in a given discipline impose their disciplinary standards on academics from other disciplines? If the answer is yes, which discipline should impose its standards on other disciplines? Who are those who are going to make this kind of decisions? Should self-appointed gatekeepers of what they call "good science" impose their criteria by means of smearing who does not agree with them? Is that scientific? Is that ethical? Should intellectual intolerance be tolerated in the academic world? Shouldn't different academic perspectives be allowed and intellectually honest disagreement be allowed and even promoted and encouraged, especially in the universities and in research centers? Should the intellectual intolerance be considered as unethical behavior en Academia? Is it ethical not to, at least, try to stop or ameliorate any intellectual bullying in the academic world? How many academics are aware about the intellectual intolerance. bigotry, and bullying that is happening (according to an increasing number of academics) in the academic world?

THE EVENT OF WMSCI 2005 AS A CASE STUDY

The above mentioned example was input to a "case Study" that generated about 150 written and published pages. Thanks to this case study a new Peer Reviewing Methodology emerged that took into account not just the ethical dimension but also the meta-ethical one. This Case study was presented at a Workshop sponsored by the USA's National Science Foundation which included Faculty and PhD Students in Business Administration of the University of South Florida. A short article has been written regarding this case study; which we are including as an appendix of this article. It is a short article with pointers to larger articles with more details regarding the Action-Research project which supported (and still supports) the finding of potential solutions (or improvement of the implemented ones) for this ethical and meta-ethical problem.

¹⁷ see for example

http://meetings2.informs.org/sanfrancisco2014/abstra ct_contributed_i.html

It is important, for our purposes in this article, to note that computing writer Stan Kelly-Bootle¹⁸ (2005) commented in ACM Queue that many sentences in the "Rooter" paper [accepted for presentation at WMSCI 2005, not necessarily for publication] were individually plausible. He thinks that this fact poses a problem for automated detection of this kind of articles and suggested that even human readers might be fooled by the effective use of jargon. He concluded as follows "I suppose the conclusion is that a reliable gibberish filter requires a careful holistic review by several peer domain experts. Each word and each sentence may well prove individually impeccable, although nonsense in toto, which probably rules out for many years to come a computerized filter for both human and computergenerated hoaxes." This is an important conclusion for the purpose of this article, because it shows that *peer* reviewing methodologies should include a meta-ethical ingredient. Consequently, we thought that a combination of Action-Research, Action-Learning, and Action-Design would probably be an effective approach to incrementally design a peer-reviewing methodology that would include meta-ethical methods or procedures. As a result we think we designed a methodology which is more effective than the known ones. It is perplexing that with all previous failures in peer reviewing we found no explicit attempt in designing, implementing, and testing a more effective methodology. We did find many suggestions about how peer-reviewing might be improved. We actually included some of these suggestions in our methodological design, but we did not find any reference to the *implementation* and testing of a more effective peer reviewing methodology.

The events described above that happened after Stan Kelly-Bootle published the above mentioned article show clearly that he was right. Methodologies of quality assurance in Science proved not to be effective even in the approval process of doctorate dissertations. The Bogdanov Affair is an example regarding this issue. In Callaos (2011) we resumed this affair that included an incoherent Ph. D. dissertation as follow:

http://queue.acm.org/detail.cfm?id=1080884

"Five meaningless papers had been published by four leading journals in physics, and served as basis for the approval of the two Ph. D. Dissertations of the Bogdanov brothers. ... John Baez, a physicist and quantum gravity theorist at the University of California at Riverside, moderated a physics discussion group entitled "Physics bitten by reverse Alan Sokal hoax" brought widespread attention to the Bogdanoff affair. Baez (2004) asserts that "Bogdanovs' theses are gibberish to me - even though I work on topological quantum field theory, and know the meaning of almost all the buzzwords they use. Their journal articles make the problem even clearer...some parts almost seem to make sense, but the more carefully I read them, the less sense they make... and eventually I either start laughing or get a headache... all they write about them is a mishmash of superficially plausible sentences containing the right buzzwords in approximately the right order. There is no logic or cohesion in what they write... Hermann Nicolai, editor of Classical and Quantum Gravity, told Die Zeit that if the Bogdanovs' paper had reached his desk, he would have immediately sent it back: 'The article is a potpourri of the buzzwords of modern physics that is completely incoherent'." (Baez, 2004). The editors of the journals where the articles were published reacted in different ways. "The editors of Classical and Quantum Gravity repudiated their publication of a Bogdanov paper, saying it 'does not meet the standards expected of articles in this journal'... Dr. Wilczek stressed that the publication of a paper by the Bogdanovs in Annals of Physics had occurred before his tenure and that he had been raising standards. Describing it as a deeply theoretical work, he said that while it was 'not a stellar addition to the physics literature,' it was not at first glance clearly nonsensical. 'It's a difficult subject,' he said. 'The paper has a lot of the right buzz words. Referees rely on the good will of the authors.' The paper is essentially impossible to read" (Overbye, 2002). Dean Butler wrote in Nature that "the credibility of the peer-review system and journals in string theory and related areas is taking a battering." George Johnson wrote an article about the Bogdanov affair in the New York Times, concluding that: "As the reverberations from the affair begin to die down, physicists seem to have accepted that the papers are probably just the result of fuzzy thinking, bad writing and journal referees more comfortable with correcting typos than challenging thoughts". In the same article Johnson added that "Dr. Sokal seemed almost disappointed." affirming that "If someone wanted to test a

¹⁸ STAN KELLY-BOOTLE "born in Liverpool, England, read pure mathematics at Cambridge in the 1950s before tackling the impurities of computer science on the pioneering EDSAC I. His many books include *The Devil's DP Dictionary* (McGraw- Hill, 1981) and *Understanding Unix* (Sybex, 1994). *Software Development Magazine* has named him as the first recipient of the new annual Stan Kelly-Bootle ElecTech Award for his "lifetime achievements in technology and letters." Neither Nobel nor Turing achieved such prized eponymous recognition. Under his nom de-folk, Stan Kelly, he has enjoyed a parallel career as a singer and songwriter." Copied from

physics journal with an intentional hoax, I'd say, `more power to them'...What's sauce for the goose is sauce for the gander." (Johnson, 2002; emphasis added)."

Baez (2010) affirms that "Jackiw, a professor of physics at MIT, was one of two `rapporteurs' who approved Igor Bogdanoff's thesis. Overbye [2002] writes: Igor's thesis had many things Dr. Jackiw didn't understand, but he found it intriguing. "All these were ideas that could possibly make sense," he said. "It showed some originality and some familiarity with the jargon. That's all I ask."

Ignatios Antoniadis (of the École Polytechnique), who approved Grichka Bogdanov's thesis, reversed his review later. He told *Le Monde*, "I had given a favorable opinion for Grichka's defense, based on a rapid and indulgent reading of the thesis text. Alas, I was completely mistaken. The scientific language was just an appearance behind which hid incompetence and ignorance of even basic physics."¹⁹ Other readers of the thesis claimed that they did not understand everything in it and they supposed that other readers do understand what they do not understand.

It is really perplexing that after the Bogdanov affair no one seemed to care about improving the quality assurance of Ph.D. dissertations and/or of peer reviewing in scientific journal, not even in Physics. Isn't that astonishingly perplexing? Why no one cared about taking the Bogdanov affair as a case study in order to improve the effectiveness of Ph.D. dissertations quality assurance and/or the effectiveness of Peer Reviewing? Is this kind of negligence ethical? Is it ethical just to denounce the Bogdanov Affair and announce the intention of making changes as to avoid similar situations? Is it ethical to just blame to the previous department chair and do nothing else regarding this kind of affair? We are not sure about the answers to these questions and this is why are making them? Our intention in making these questions is not a rhetorical one. This is why we think that each case like the examples shown above should be taken as a <u>case study</u> oriented to continuously improve the effectiveness of peer reviewing methodologies.

SOME CONCLUSIONS

The following are among the conclusions we can make with regards to the content of this paper, which are also based on 1) the experience/knowledge we acquired through the Case Study of the WMSCI 2005 event, 2) the experience/knowledge we gathered through an incremental design and implementation of the peer reviewing methodology mentioned above, and 3) the information we gathered regarding similar events, e.g. the examples mentioned above.

- One of the most important conclusions is that the 1. most frequent source of the peer reviewing methodologies being used is for cases where scientific misconduct of authors coincide negligence or misconduct of reviewers of the respective article. Consequently, *a peer reviewing* methodology should have a meta-ethical ingredient related to both potential sources of misconduct: the authors and the respective reviewers. On the other side, academic departments and deanships as well as universities administrators and authorities should explicitly address the Academic Ethics and Meta-Ethics via caring and enforcing the expected ethical behavior in academic issues. It is our opinion that ethics enforcement should be less soft and more rigorous.
- 2. Double-blind reviewing facilitates and sometimes it might even catalyze the coincidence of author's misbehavior and reviewer's negligence or misbehavior. In double blind reviewing the authors names are not supposed to be published as related to the respective author. So, how would it be possible to include a meta-ethical ingredient with regards to reviewers' possible negligence or misbehavior in the context of this anonymity situation? This is why we added to the traditional double-blind reviewing a second reviewing tier with non-anonymous reviewers. In this sense, David Kaplan was our inspiration through his article "how to Fix Peer Reviewing" (Kaplan, 2005)
- 3. As we suggested above, we are convinced that the effectiveness of the Scientific Enterprise might be improved if grant Organizations and the academic promotional procedures relies less on structures based on the traditional peer reviewing methodologies.
- 4. If academic promotions are going to continue being based on journal publications and journal quality is going to be measured by its impact factor, the respective measure should not be limited to the relative quantity of citations of the respective journal. There are increasing efforts in addressing this issue.
- 5. Academic departments should make their own definitions of what is a peer and what peer reviewing methodologies will be acceptable for the discipline of the department.
- 6. Standards of some disciplines should not be imposed on other disciplines, because this might corrupt the

¹⁹ Hervé Morin, 2002.

nature of the discipline on which the other standards are being imposed.

- 7. More intellectual efforts should be done in creating awareness with regards to differentiating and not confusing the *ends* with the *means*, and not taking the means as ends in themselves; which certainly is ineffective with regards to the real ends and it might corrupt the nature of the means. Publication is a means, impact factors is a measure (among many other possible ones) of one of the properties of a mean; it is not and should not be an end in itself.
- 8. There is an increasing necessity and urgency in addressing both the ethical and the meta-ethical dimensions of any research activities, not just as a moral issue but also as a **pragmatic** one.
- 9. To use systemic (not necessarily systematic) peer reviewing methodologies which are adaptable (to different disciplines, for example) and might perfect themselves in the context of an evolutionary process based on an adequate *integration of Action-Research, Action-Learning, and Action-Design*, in the context of a meta-methodological incremental planning and evolutionary methodological re-design and meta-design.
- 10. This conclusion is based on our interpretation (or informed opinion, or judgment) regarding some ways which were taken by some academics (and graduate students) to deal with the problems that emerged from academics who misbehaved, or from the intrinsic failures and weaknesses of the traditional peer revising methodology which mostly is being used. In our opinion more attention should be paid to Intellectual Intolerance and to the increasing academic cyber-bullying and cyber-inquisition being practiced by some academic vigilantes who are selfnominated prosecutors, juries, and judges on the name of what they consider "Good Science". Some of these people are well intentioned scholars but they are not aware that they are forming part of lynching mobs and that they are being mislead by people with vested interests or promoting autocratic (and consequently anti-academic) Intellectual Inquisitors. We understand that this is the result of speech freedom and academic autonomy. We also understand that tenured professors should be able to speak their mind; which is very important in honest scientific disagreement and academic freedom. But, is it right to use this freedom to smear prestigious organization like IEEE, ACM, ASME, SIAM, Springer Verlag, etc.?²⁰ Is this ethical? What

academic criteria are being followed when smearing all conferences of these organizations that have been adequate support for academic and providing professional activities for so long time? Should the deficiencies of peer reviewing be used to smear and defame so many academic and professional organizations? Is that ethical? For how long we should have an intentional blindness not identifying the inherent of peer reviewing and continue blaming its failures on the organization using them? Isn't an ethical obligation to identify the right problem and to try to fix it? We are not talking here just about anonymous bloggers, but also about academics and librarians that have earned the respect of some of their colleagues. Did these scholars and librarians thought about the harm they are doing to the same scientific processes and academic activities they are supposed to be protecting, with very good intentions in some of them. Did they think about the ethical issues of their behaving? Are they unintentionally misbehaving? Did they think about the new kind of inquisition in which they are being acting, simultaneously, as prosecutors, judges, juries, and executioners by means of web pages that they create, in which they lump together many organizations and refer to them as predators? In the hypothetical case that all what they are listing are predatory journals or organizations²¹, aren't they meta-predators, masked with vigilantes of scientific and academic activities?

²⁰ See for example <u>http://fakeconferences.blogspot.com/</u>.

^{20,100} results are showed when entering "IEEE bogus conference" in Google. 5,890 results when entering "ieee fake conference".

²¹ See for example at http://scholarlyoa.com/publishers a list of what have been named as "Potential, possible, or probable predatory scholarly open-access publishers." This list is being taken into account in processes of academics and librarians promotions. Editors of journals and organizations included in this list were not asked about their peer reviewing processes. The criteria to define them were generated by one person and any journal not following these criteria are immediately included in the list. Is this academically ethical? Is it academically ethical not to seek the truth and to impose the criteria of one person on the labeling of journals as predators? Is it ethical to use this list in decisions oriented to academic promotions? Furthermore, the criteria followed to define this list automatically exclude any academic innovation and/or entrepreneurship. We were informed about the good intention of the librarian who produced this list, and we do not have any doubt about it. But, is this really the way to deal with unethical behavior of some publishers? Is it ethical to smear so many journals and organizations just because they do not follow the criteria of a well intentioned librarian? How many academics were hurt in their careers just because they published in some journal listed in the list. Should departments' chairs and deans use this list in their decisions regarding the promotion of academics? Is that fair? Is that ethical? These are no rhetorical question, but questions that has been made in order to trigger reflections on this kind of issues.

Are they solving the real problem? Are they contributing to the solution of the right problem? Can we blame journals editors and conference organizers for the misbehavior of reviewers and/or authors? Can we blame them for the constant failures of the traditional peer reviewing methodology? Can we blame the driver for consequences of an accident was required to because he/she drive а malfunctioning car? Who is to blame? The driver? The car manufacturer? The boss who required the driver to drive this car? What would be the ethical and practical answer? Is an ostrich strategy an ethical and practical one? Should we address the real problem which is a very complex one instead of doing simple tasks that, far from solving the problem, might create more problems and potentially hurting innocent people by smearing their character, integrity, and honesty? Is this ethical? Is this fair? Is this practical? Is this congruent with the main purpose of Academy which is to always seek the truth?

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APPENDIX

Improving Peer-Reviewing: A Case Study Triggered by the Acceptance of a Bogus Paper

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Presented at the Workshop on "Using the Case Method for Instruction" Funded by The National Science Foundation

Held in College of Business of the University of South Florida, Tampa, Florida, USA,

Participants: Faculty and doctoral students interested in using the case method, developing discussion and research cases, and employing classroom and distance technologies.

Organized and facilitated by Professor T. Gordon Gill, University of South Florida, USA

PURPOSE

The objectives of this very short paper is 1) to briefly describe the sequence of the search/research activities that were triggered by the acceptance of a fake paper submitted to WMSCI 2005 and 2) to present the different reports that were generated by means of a) literature search regarding this kind of problem, b) the published potential solutions, and c) the implemented solution, which was identified by a methodological research fundamentally based on *action-research, action-design*, and *action learning*. At least 3000 hours (of senior academics, conference organizers, and journal editors) have been invested in this case study.

In this short paper, we will make a very short description with links to other detailed and larger papers which are being generated as a consequence of this case study and the tentative solutions that has been implemented, which in turn might provide input for more case studies regarding this important issue of improving peer reviewing processes.

MAIN EVENTS

The respective main events and search/research activities have been, up to the present, the following:

1. Randomly generated papers were submitted to WMSCI 2005. Some of them were identified as such by their respective reviewers and were rejected. No reviews were received for one of them and then according to the published policy of the Organizing Committee, the paper was accepted as a *non-reviewed* one, because of the **CVs** of its respective authors (three MIT's PhD students). They were told that the paper will be included in the proceedings (with an explicit note) as a *non-reviewed paper*, but if the Organizing Committee

received reviews recommending the acceptance of the paper then its status would change to a peer-reviewed one. A more detailed description, where facts were separated from reasoned opinions and judgments, can be found at <u>www.iiis.org/wmsci2005-facts-and-reasoned-judgements</u> (15 pages)

- 2. All hell broke loose after the email acceptance was sent. Reuter distributed the news as "a computer generated paper was accepted for presentation at a computer science conference." BBC, CNN, Boston Globe, etc. published the news. Half truths and blatant smearing and lies, as well as personal attacks invaded the blogosphere related to Computer Science.
- 3. Our huge surprise was that, even after the above mentioned events, we received reviews recommending the acceptance of the gibberish paper. This event couldn't be more astonishing and disconcerting to us. Was something wrong (unethical) with some of our reviewers? Was something wrong with our reviewing methodology? How could we have a more effective reviewing methodology?
- 4. Point 3 triggered a search process for more information and the more information we gathered the more certain we were that we needed a reviewing methodology different to the traditional and most used one. Parallel to the literature search (not research), we organized conversational sessions and focus groups in the context of the 2006, 2007, and 2008 conferences. Interested attendees of these events were asked the questions that our search was producing. Results of these conversational sessions were included as appendixes of the document posted at <u>http://www.iiis.org/nagibcallaos/peer-review/</u> (pages 76-107).

5. Results of the processes described in point 4 triggered action-research processes which produced action-design and action-learning processes, in the context of an incrementally-evolutionary methodology to identify the ways of improving traditional double-blind peer reviewing methods.

CONCLUSIONS OF THE SEARCH/RESEARCH

- 1. The most essential conclusions were as follows
 - a. A high level of agreement among reputable *journals'* editors regarding the low effectiveness, weaknesses, and high frequency of failure in peer-review methods. Combining these opinions, perceptions, and facts with the huge amount of time spent (invested?) in peer reviewing, it is easy to conclude that we are facing an important problem that require some solutions. It is estimated that 15.000.000 of yearly hours of work are used in peer reviewing processes (more than what the USA invested in the whole Genome Project); about one billion dollars each year while (according to a survey of members of the Scientific Research Society) "only 8% agreed that 'peer review work well as it is'." So, is peerreviewing cost-effective? Details regarding the high level of agreement regarding the low level of effectiveness of peer review can be found in pages 1-20 of the report posted at http://www.iiis.org/nagib-callaos/peer-review/
 - b. No agreement regarding a standard peerreviewing methodology.
 - c. Lack of agreement regarding the meaning of "Peer" and "Peer-Review." More details at <u>http://www.iiis.org/nagib-callaos/meaning-of-</u> <u>peer-review</u> and at <u>http://peerreviewing.wordpress.com/2012/05/</u> <u>19/meanings-of-peer-and-peer-review/</u>
 - d. Lack of agreement about what a conference is and what are, or should be, conferences' objectives. In one extreme, some conferences have peer reviewing standards similar to journals in the respective discipline. In the other extreme, there are reputable conferences with no peer-review at all. Examples are the meetings of the American Mathematical Society: AMS, The Southeastern International Conference on Combinatorics, Graph Theory, and Computing, etc. (http://blog.computationalcomplexity.org/200 7/11/unrefereed-does-not-equal-bogus.html). disciplines Different have different conceptions regarding this issue. Then, what

should a multidisciplinary conference do with this regard?

- e. Lack of explicitly written information regarding what a conference's proceedings is and what it should contain.
- f. Disagreement among different disciplines with regards to their conceptions of what "conferences" are for and what is, or should be, the functions of their respective proceedings. Consequently, <u>what should a</u> <u>multidisciplinary conference do regarding</u> <u>this issue?</u>
- g. A more adequate reviewing methodology was needed, especially for multi-disciplinary conferences organized for inter-disciplinary communication.

POTENTIAL SOLUTIONS

With the above mentioned results of our search, we tried to design and implement a *Reviewing Methodology for a multi-disciplinary conference* and to explicitly publish what we understand by each of the concepts, objectives, functions, and notions where no explicit standards or implicit agreement exist. The meta-methodological process we have been (and we are still following) following is based on a combination of *action-research, action-design, and action-learning in the context of an evolutionary, incremental, and cybernetic process.*

Up to the present we obtained the following results

- 1. We identified the objectives of peer-reviewing: pages 20-35 of the report posted at <u>http://www.iiis.org/nagib-callaos/peer-review/</u>
- 3. We proposed possible solution in pages 35-39 of the document mentioned in point 1. This solution has already been implemented with a reasonable level of effectiveness and success.
- We proposed A Systemic Model of Scholarly and Professional Publishing and the architecture of its respective supporting information system in pages 39-61 of the document mentioned in point 1. (Also at <u>https://www.academia.edu/4437267/Systemic-</u> <u>Cybernetic model for reviewing and publishing</u>). We implemented about the 80% of what has been proposed but because of financial lack of support the

proposed system has not yet been completely developed.

- 5. We proposed and we are working with a three-tier reviewing methodology:
 - a. Traditional double-blind with a minimum of 3 reviewers and with an average of about 4 actual reviews as reported in the forewords of the respective proceedings.
 - b. Non-anonymous, non-blind with a maximum of three reviewers.
 - c. Peer-to-peer reviewing (the reasoning supporting this kind of review is presented in pages 61-67 of the above mentioned document.

More details regarding this methodology can be found in "A Multi-Methodological Reviewing Process for Multi-Disciplinary Conferences" that is being posted at all conferences sites, e.g. <u>http://www.iiis2014.org/wmsci/Website/MMRPfMDC.</u> <u>asp?vc=1</u> A short description of a basic two-tier methodology has been posted at <u>http://iiis.org/peerreviewing.asp</u>

- 6. We posted in all conferences sites what are, for us, the objectives of conferences and the functions of the respective proceedings. What we posted was the results of many conversational sessions and focus groups with attendees of our conferences. http://www.iiis2014.org/wmsci/Website/FunctionsofConferencesProceedings.asp?vc=1
- 7. We have been successfully using a newly designed two-tier methodology for Peer Reviewing in which we combine *traditional double-blind* peer reviewing as a <u>necessary</u> condition, but not as a <u>sufficient</u> one. A nonblind peer reviewing is also required in the methodology we are using since 2006. A short description of this methodology can be found at page <u>http://www.iiisci.org/Journal/SCI/Methodology.p</u> <u>df</u>

We posted in the web as many documents as we could in order to continue with the collective efforts of the IIIS's members and its conferences' attendees in contributing for a continuing improvement of the effectiveness in peer reviewing and in adapting the objectives of the conferences and the functions of its respective proceedings to the users of our conferences, who are their actual attendees. Continuing with this process is the essence of the metamethodological process we are following which combines action-research, action-design, and action-learning in the context of an evolutionary, incremental, and cybernetic process, by means of collective contributions to this process.

A Significantly Indicative Event Happened After the Presentation Was Made at the Workshop (which was resumed above)

The peer-reviewing methodology, briefly described above and in the linked references seems, to have been quite <u>effective</u> especially if we take into account that "The publishers Springer and IEEE are removing more than 120 papers from their subscription services after a French researcher discovered that the works were computergenerated nonsense."

(http://www.nature.com/news/publishers-withdraw-morethan-120-gibberish-papers-

<u>1.14763?WT.mc_id=TWT_NatureNews</u>). Since 2006, all fake papers we received were identified by our two-tier methodology which is described with more details at <u>http://www.iiis.org/journal/sci/Methodology.pdf</u> and <u>http://www.iiis.org/acceptance-policy.asp</u>. Even we cannot prove that our methodology is more effective (but less efficient because it requires more persons-hours in peer reviewing and acceptance processes), we have several reasons and indicators to believe that it is definitely more effective. One of this indicators is the recent news regarding prestigious publishers trying to remove about 120 fake papers from their publications, while no case has been presented up to the present with our two-tier methodology.

Improving Interdisciplinary competences for effective communication in technology academic profiles oriented to hardware and software networking

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ABSTRACT

Traditional academic profiles had been oriented either to hardware or software study, aiming towards telecommunications or control systems predominantly, considering both lower or upper layers of the OSI networking model. Actual syllabus requires that professionals acquire new competences to communicate with legacy profiles and diversity of new ones all over the world regarding these areas of knowledge. Collaboration in communities is a new competence if we consider the inclusion of free hardware, open source, group based learning and social problems. This work proposes a framework to identify in one organization how to recognize and how to manage interdisciplinary drawbacks although new interdisciplinary profiles are present like Electrical Engineering and Computer Science, Electronic Engineering and Computer Science and Telecommunications Engineering. Three case studies are presented to identify the new interdisciplinary competences required, and how to manage the learning process. One case presents the creation of a professional social network, the second presents the teaching process in Telecom Sud Paris (France) and entrepreneurship, another case presents entrepreneurship process in the company TELEFÓNICA Venezuela. In the three case studies, the ecosystem needs a staff with competences on hardware, software networking and socialtechnological skills. This last type needs to be included in syllabus of new academic profiles through techniques like group based learning. Interdisciplinary competences must be inserted in syllabus and also be learned with experience.

Keywords: profile, collaboration, syllabus, legacy, interdisciplinary.

1. INTRODUCTION

There is a relationship between the history of the use of electricity and the development of curricula to form the Electrical Engineer, Electronic or equivalent in all the universities of the world to the present [1]. It all began in 1882, when the teaching of electricity started in American and European universities in the late nineteenth century. In England, formal education of electrical circuits began in the area of physics. The first courses of Electrical Engineering in the american continent, primarily in university work started in the early 80s of the XIX century in centers such as Cornell University and MIT (Massachusetts Institute of Technology). A close relationship was sought between universities and industry, and produced a change in the curriculum, so it evolved from scientific to technical, unlike other engineering process. The same method was used in Germany, Japan and other countries, where industrial development was crucial to the emergence of institutionalized education in universities. As a consequence of the development in the areas of electronics, computers and telecommunications during the twentieth century and early twenty-first century, new syllabus have been created. For instance, Electrical Engineering and Electronic Engineering have been replaced with Electrical Engineering and Computer Science (EECS) developed at MIT [2] and the University of Berkeley [3] in the United States. In Europe, a new curricula to train professionals with the profile of Engineering in Electronics and Telecommunications exist, oriented to Transmission or Telematics. Additionally, this profile can be complemented for specialists (at masters and doctoral studies). In Asia, a profile named Electronics Engineering and Computer Science has been defined [4].

2. NEW EXISTING PROFILES

In North America, during the last decade, a new profile exists in universities named Electrical Engineering and Computer Science. This new approach integrates four intellectual themes: the design of complex systems, modeling and controlling systems, augmenting physical systems with computation and building systems that are robust to uncertainty. The contents are tought in a practice-theory-practice basis.

In Europe, since about ten years new profile named Telecommunications Engineering with mention Transmission or Telematics exists within universities, particularly in Spain [5] and Italy [6]. A profile named License in Electronics exists in France [7] and can be oriented to both hardware and software, and Telecommunications Engineering exists on the specific schools like Telecom Sud Paris [8] or in other French universities. In south America, it is very common to find professionals with new profiles working together with legacy profiles like Electronics Engineering. In India the career Electronics and Telecommunications Engineering exist [18].

In Latin America, interdisciplinary is not enough due to diverse social and economical causes [9]. There has been a tendency at Universities to prepare professionals mixing traditional and new profiles like Electronics Engineering mention Telecommunications or Control. Even in developed countries, mixed profiles mastering aspects on software, hardware and telecommunications work together just to solve social problems. Electronic Engineering career is oriented to the hardware and lower layers of OSI model. In the opposition, Software Engineers or Computer Science professionals careers are oriented to the software and upper layers of OSI model.

With the spreading use of wireless and social networks [10], several professional profiles area necessary to solve technological problems, not only technical ones but also social community. The interdisciplinariety in developing countries and in developed countries require professionals that manage the seven layers of the OSI model, and specialists focused in one or more aspects of the physical phenomena, described from a digital or analogical point of view.

The profiles on hardware, software and telecommunications can be classified into 3 main groups:

Group 1: Electrical Engineering and Computer Science and equivalent profiles.

Group 2: Telecommunications Engineering and equivalent profiles.

Group 3: Legacy profiles. Electronic Engineering.

The Table 1 shows some existing careers in different universities.

Table 1 Groups of main existing careers

Group	Careers	Universidad	
1	Electrical Engineering and	MIT (USA)	
	Computer Science		
1	Electrical Engineering and	UC Berkeley	
	Computer Science	(USA)	
2	Electronics and	University of	
	Communications Engineering	Mumbai(India)	
1	Electronics Engineering and	Beijing (China)	
	Computer Science		
2	Telecommunications	La Sapienza	
	Engineering	(Italy)	
2	Telecommunications	Cantabria (Spain)	
	Engineering		
2	Telecommunications	Antioquia	
	Engineering	(Colombia)	
2	Telecommunications	Telecom SudParis	
	Engineering	(France)	
2	Telecommunications	Telecom Lille	
	Engineering	(France)	
3	Electronic Engineering	Antioquia	
		(Colombia)	
3	Electronic Engineering	Rosario	
		(Argentina)	
3	Electronic Engineering	Sao Paulo (Brasil)	

Actually, new and legacy profiles permit exchange knowledge and experiences about the communications phenomenona just to analyze or design solutions. Moreover, both analogic ad digital systems coexist on telecommunication and networking systems.

3. NEW REQUIRED COMPETENCES

The innovation and maintenance of information and telecommunication systems require professionals with competences on analysis and design of technical solutions. In Fig. 1 some key words that permit identify such competences are shown.



Fig. 1 Key terms of competences

However collaboration activities and representation of groups have been increased on the 21st century due to the propagation of the use of Internet in every environment. In fact, societies are becoming as part of the "Internet of Things", or more recently as "Internet of Everything". This means that new competences related to group working and group based learning need to be included on the new profiles. We can categorize these new competences in three big areas of skills: free hardware, open software and social-technological as follows.

Free hardware skills

This group of new competences contains skills to design, implement and assemble hardware solutions for computer architectures, smartphones or any digital system devices that uses a microcontroller or microprocessor when different profiles are present. Skills to search parts and manage the commercial language are important for an engineer.

Open software skills

This group of new competences contains skills to design, implement and integrate software solutions for software engineering for any device that requires a program to operate when different profiles are present. Modeling and simulation with tools based on graphs theory is required for representation of trees as sharing of information is a reality. This includes both proprietary and open source projects.

Social-technological skills

This group of new competences contains skills to identify needs on the everyday life, to communicate with professionals formed with both new and legacy profiles from any country. Some framework has been developed based of Ethos, Pathos and Logos conception. Skills related to the health and behavior are also important as social networking and wireless technologies are present on the everyday life. This is the main group where the interdisciplinary competences are present: decision taking, marketing, effective technological communications, tolerance between cultural key values.

4. CASE STUDY: DEVELOPING A PROFESSIONAL SOCIAL NETWORK

A group of professionals are willing to create a new professional social network. The engine requires the profiles of new members so that it can recommend new bindings among actual members. This database is filled out by the new and old members. It includes academicals issues like studies, professional experience and skills, nationality and actual country, spoken languages, hobbies and historical of consulting other members. The system needs to be accessed via wireline or wireless internet and provides security. Only information that is public is allowed by the member. The employers might have any profile, not necessary any of those shown in Table 1. However, the leader must have interdisciplinary competences to understand the whole system. To create the social networks the following steps are taken:

1) Description of vision and mission of the society: these permit establish the focus of the social network.

2) Establish the location of main headquarter, and optional branches. Redundancy for failing tolerance keeps the system active.

3) Define the networking infrastructure: devices and physical mediums for interconnectivity indoor and outdoor. A datacenter is commonly used in social networks.

3) Development of distributed system. Definition of database must be done.

4) Fill out the database with information provided by interested users. Maintenance of the hardware and software platform or networking needs to be permanent.

5) Establish logic relationships between the subscribers by using models. Theory of graphs applied to organize hierarchies based on any criteria: initial individual information plus new relationships between members.

The three groups of new competences required to participate on the project are the following:

Free hardware skills

The hardware constitutes the physical support of the information and serves also for the transmission of the information from the members to the datacenter and vice versa. The organization is also trying to develop a new smartphone model with specific applications that permit connect directly with database. Some end devices will be constructed based on Raspberry-PI [11] or Arduino [12] architectures. Backbone networking equipment consists of routers, switches and servers.

Open software skills

The information system is supported by a database manager. An operating system needs to have fast responses to the access of data and security. Some APIs are provided to the end users so that they could create new applications. Partial information is provided to the end user. There is one logical representation of data based on graph theory, and social aspects.

Social-technological skills

This group of technical staff needs competences to exchange information related to hardware and software networking. Terms like: platform, medium, protocols, sockets, datagrams are part of common working language. Professional must deal with sociology concepts [10], that permit identify and characterize members according to their preferences and human relationships.

5. CASE STUDY: TEACHING NEW INTERDISCIPLINARY COMPETENCES IN TELECOM SUDPARIS (FRANCE)

Free hardware and open software skills can be acquired by providing the technical content with new and legacy academic profiles. Group based learning and work together with communities, the enterprise and the government help acquire social-technological skills. An international internship permits acquire adaptation skills and also helps the student create a model that can be used on future exchanges of ideas and innovation, which is precisely the technological transfer. The interdisciplinary competences can be more easily acquired within universities where there exists diversity in careers than in more specific ones.

For instance, Telecom & Management SudParis[8] is one of the telecommunications and management institutes where both areas are merged in France. They coexist together just to provide interdisciplinary competences to the future telecommunications engineer. The entrepreneurship activities are very common so that the innovation can be done, but also be supported by other disciplines. Two foreign languages are part of the syllabus a mandatory and another one is optional, and it is recommended to participate in an international internship for management students.

Contests of business plans are done each year just to generate the ideas. A start-up produces the innovation and prototype.

Telecom & Management SudParis has a special dependency named T&M Entrepreneur [13] where specialists on social-technological skill give support.

6. CASE STUDY: ACQUIRING NEW INTERDISCIPLINARY COMPETENCES WITH TELEFONICA (VENEZUELA)

In the case of Venezuela, the enterprise TELEFONICA (Spain) supports this interdisciplinary learning process with the WAYRA-Venezuela project [14]. A contest of business plans is done each year. The winning proposals are implemented down to the earth in a period of one year with support of TELEFONICA. On this case, the proposals come from one university or a start-up. Most enterprises have been created by professionals, not by students.

The submitted projects for evaluation, might integrate description of the staff members with some skills on free hardware (end user devices and backbone), open software (an information system, and smartphone software) and social-technological issues (marketing, sociology, economy). The start-up can be created from one University or particular, in the way they are created in Silicon Valley (California, USA).

However, there is still one gap between universities and enterprises on telecommunications in Venezuela, since the economy is mainly based on Petrol, where this relationship is much stronger. The universities need to include on the syllabus some content that help undergraduate create start-ups. Interdisciplinary skills are required.

7. ECOSYSTEM FOR NEW INTERDISCPLINARY COMPETENCES

Technical staff of electronics, software and telecommunications must work together with other professionals to generate new ideas and achieve cross-fertilization. The learning process must begin at the university. Engineers formed with Legacy profiles (Electrical or electronics engineer) will exchange data and methods with new professionals (Electrical Engineer and Computer Science, Telecommunications Engineers) and with professionals from other careers (managers, economist, sociologist, and others).

This is one of the key ideas that permitted NOKIA enterprise become a leader of cellular telephony, and has a strong role on the development of the second generation with GSM technology [15]. They included professionals from other nationalities and profiles in their staff, and the innovation was not just based on functionality but also in artistic aspects. We propose an ecosystem that can help integrate universities, enterprises, governments and research centers. This works also for professional training environments. The ecosystem consists of actors, contents and activities that permit collaboration between professional of different areas and profiles by using hardware, software and networking technical competences. The knowledge must be mixed up with experience and social needs to solve community problems [16].

In Fig. 3 we show the ecosystem proposed.



Fig. 3 Ecosystem with effective interdisciplinariety

The universities teach and do research according to the social problems. Some of such problems are found by the researchers themselves, other by the enterprises [17], government members or by research centers. The budgets for the projects come from several sources like, national science foundations of each country, investors and partners. However, the executors of solutions coexist within the ecosystem and it is required effective interdisciplinary communication. For each problem to solve, a staff must be allocated as human resources. Some special members can be named as Gateways since they serve as listeners and talkers.

The actors can be classified on members, TGs, HGs and EGs.

TG stands for Technical Gateway, consists of a member that has mixed profiles like Electric Engineer and Computer Science. HG stands for Human Gateway, consists of a member that can interact with other members belonging to types linear active (Logos), multi active (Pathos) or Reactive (Ethos) [19]. EG stands for Experience Gateway, consists of a member that has been involved with at least two of the main sectors: government, enterprises, universities or research centers.

Fig. 4 shows the interdisciplinary exchanges. On the higher square we represent the new and legacy profiles, on the lower square we represent the interdisciplinary skills that must be acquired mainly in developing countries. Managers must have an important role on the integration of different profiles.

These three type of gateways are key actors in a interdisciplinary project. Particularly in projects where multinational partners work together, it is specially important the presence of the HG since technical language is also related to culture and engineering standards. Interoperability is also a trend that permits interaction among different systems, and has the same function as gateways on the machinery level[20].



Fig. 4 Representation of interdisciplinary skills

8. CONCLUSIONS AND PERSPECTIVES

Effective interdisciplinary competences must be acquired by members of professionals that will be in charge of organizations to solve social problems. In particular, professionals who have legacy profiles like Electronics Engineer, or Computer Science Licence need to exchange information, and work together with professionals that have new profiles like: Electrical Engineer and Computer Science, Telecommunications Engineer or any mixed one. All of them require competences of free hardware, open software and social-technological types. The acquisition of these competences permits interaction with the other professionals and with the community.

However, interdisciplinary communication skills are learned when different actors work together. To facilitate this exchange of knowledge and experiences, we propose a model of ecosystem that contains special actors that are present in a different layer: a Technical Gateway (TG) permits the interaction between different profiles regarding hardware, and software networking. A Human Gateway (HG) permits the interaction between different personalities or cultural backgrounds. The Experience Gateway (EG) permits the interaction between different experienced members on working with government, enterprises, universities or research centers.

The technological and social aspects are strongly related since there has been a spreading process of the use of wireless networks and devices on the normal life, and of the social networks. We are moving from the "Internet of things" through the "Internet of everything". Future work is aiming to analyze how this ecosystem can describe new tendencies on a hospital or clinic in the health domain.

9. ACKNOWLEDGEMENTS

The authors thank to the Consejo de Desarrollo Científico y Humanístico (CDCH) of the Universidad Central de Venezuela for the Budget assigned to the project: "Mejoramiento de arquitectura para servicios multimedia basada en multidifusión IP" under the identification PI-08-7820-2009/1 that permitted propose a new interdisplinary framework.

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*When Robots Play Dice:

Can technology reflect the Ethos, Logos, and Pathos of the Academy?

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Abstract

As technology becomes ubiquitous in our classrooms student bodies, and society at large, the morals and standards of a classroom of days-gone-by are held to the test. We present a series of questions and ideas that consider the possibility that technology can exercise techniques of ethos, pathos and logos, with and without the help of humans.

Introduction

Albert Einstein adroitly tells us "God does not play dice with the universe." Robots, however, are not of God -- they are of man and we, too often, have played dice with our universe -- and continue to do so.

This paper addresses the possibility that our technology, growing in its autonomy and independence from its human creators, is, indeed, evolving to the point where playing dice, messing up a board in a monopoly game, and spontaneously cracking a joke are becoming parts of its behavioral repertoire. Behaving persuasively through the precepts of ethos, logos, and pathos is programmed and embedded into our technology by virtue of its presence in its human inventors and Can our tools- our technological, authors. computer-enmeshed tools - in and of themselves, exhibit and convey information using the precepts of ethos, pathos, and logos? Our technology is melding into humanity, forming a new social and psychological order that is redefining the way we perceive technology, mankind, and its symbiotic relationship.

In our work, we address the information sciences domain didactically-- presenting the "what" and

*excerpt from the book in progress

When Robots Play Dice by Jennifer Seitzer

"how" of algorithms, systems, and computer science, but also, courageously by asking "why?" and "what if this goes wrong?" and "what else could this do to create a hopeful world for future generations?" In this paper, we look particularly at how we can endow our technology to reflect the characteristics of ethos, pathos, and logos? And moreover, how can we endow technology to foster these principles in humans?

This paper is an invitation. We invite you to consider technology as a new modality -- a symbiotic force -- that enables ours students and scholars to rise to its potential by coupling the excitement of 'doing' with the wisdom of contemplation, and to have the courage to ask the questions that enable us to continue in our evolution.



¹http://decodingcommunications.blogspot.com/2012/05/what-attributesshould-ethos-pathos-and.html

Background and Basics

In Aristotle's On Rhetoric, three public speaking devices are presented as mechanisms of persuasion: ethos, logos, and pathos [Ross 1931]. The three devices are indicated as invaluable techniques to convince one's audience, one's colleagues, one's students, of the position and degree of veracity of your presentation. Ethos is the set of nuances that collectively convince the listener of one's credibility - that you know what you are talking about. Logos is the framework of logic that one exercises to present an argument in a structured and reasonable fashion. *Pathos*. underlies both the ethos and logos in that it serves to appeal to the listener's emotions. Using, as gateways, humor, fear, joy, pity, grief, and ecstasy, among others, we can provide the listener a unique path to our message using pathos. As humans, we are continually transmitting and receiving through our senses messages imbued with ethos, logos, and pathos.

Now we are engaged in a time of enmeshed technology. We live in a time when we see, hear, wear, and use technology more often than not. Additionally, it is a time of big data. It is a time in which we are seen, heard, monitored, and logged *by* technology more often than not. How is the logging exercising ethos, logos, and pathos? Or, better yet, *is* the logging exercising these techniques? How are we, as humans, using technology to better exercise them? Or better yet, *are* we or *should* we be?

Ethos and Technology

The technology of content-providing devices such as the Web, our iPhones, the blogosphere are exercising ethos -- credibility and ethics - to the extent to which the human authors behind the content exercise them. How we use technology in regard to ethos, is dictated by our behavioral choices. The alarming reality is that it has never been easier to "burn books," to "reinvent history" or to ignore it, because of the ease with which we are able to delete or modify electronic documents. The Cloud is ephemeral – far more ephemeral than paper. On the other hand, the facility to share and use others work, in an honorable way - to find out about ongoing research, has also never been easier. The technology has made exploration and consideration easier and more accessible.

Logos and Technology

The precept of *logos* as a mechanism of persuasion, is the invocation of *logic* as the underlying skeleton of any argument. Any logic is comprised of a syntax, a semantics, and an inference mechanism *[Epp 2011]*. The syntax is its set of linguistic entities and rules that define their proper orderings in sentential communication. The semantics create a mapping between the syntactic entities to the world in which they are considered. The inference mechanism enables us to derive more syntactic entities by using pre-existent ones through inference rules such as modus ponens $(P \rightarrow Q$ along with P derives Q).

The question of whether our technological devices possess underpinnings of logic seems obvious. Their very inception and design is based on Boolean logic that possesses all three of the above constituents. The question of whether or not our technology fosters logos in their users is a bit more complex. Our tools have evolved to help us write more accurately and in a richer way, however, they have also been shown to lessen our capabilities. For example, researchers from McGill University found that avid GPS users suffer from a reduced size of the hippocampus² (the main part of the brain responsible for navigation and for learning new material of any sort). Thus, again we punt in our deduction as to whether technology helps or hinders. It seems that the underlying intention of the user is very instrumental in dictating technology's role in their mastery or ignorance of logos.

Pathos and Technology

Last, we consider the most "human" of the persuasive precepts: pathos. Pathos envelops the ability to evoke and communicate human emotions. The most common modality of emotive

²http://www.dailytech.com/Study+GPS+Units+Cause+Memory+and+Spa tial+Problems+/article20169.htm

communication is through our words. Natural language is endowed with the power to change our thoughts and feelings. In the area of natural language understanding and generation, our technology has made great strides.

The Turing Test and the Loebner Prize

In 1950, Alan Turing devised a test, the Turing Test, that purportedly indicated whether or not a machine was intelligent by foiling a human interrogator into deducing that the machine was human. The human interrogator and computer (machine) are separated so that the only input the interrogator has from the entity (possibly also human, or machine) being interrogated was the answer to each question the interrogator posed. Creation and passing of this test has long been determined to not constitute the overall goal of artificial intelligence. It does, however, shed great light on the complexities of language understanding, voice recognition, and other dominant problems in artificial intelligence.

This test gave rise to many "machine therapist" applications and bots starting with Weisenbaum's ELIZA *[Weisenbaum 1966]* as shown below in Figure 2.



Figure 2: ELIZA ... a cyber-therapist demonstrating pathos

Each year, a group of international computer scientists gather to participate in a the Loebner competition, a modern-day Turing Test contest. The competition's most revered prize, the Most Human Computer, is awarded to the computer that exhibits the most "human" qualities and the system that the judges deem to be human (i.e., the system that is closest to passing the Turing Test and, undoubtedly, exhibiting ethos, logos, and pathos in its machine generated responses). Brian Christian [Christian 2011] argues, however, that the more profound and difficult prize to win at the Loebner Competition, however, is the Most Human Human Award, awarded to a human whom the judges deemed to be human (and not a machine). In his work, he contends that technology has a great function: to show us what we are not – and thereby enabling us to emphasize and augment our humanness and our humanity.

IBM's Watson - Employed all three precepts

In 2011, a question/answering system developed by IBM named Watson, won first place on the television show, Jeopardy, against two worldchampions [Kurzweil 2011]. Watson is an unembodied computer system that is highly parallel in both hardware and software. It has been considered to be the first system that actually demonstrates some aspects of deep AI (thought processes that mimic human thought processes). Watson clearly demonstrated ethos and logos. Watson was able to employ an agglomeration of techniques over unstructured information. The system was personified in the press and was said to "not have much of a sense of humor" yet Watson necessarily employed interpretations of puns and other humor techniques in the continued successful translation of game cues, and thus, also demonstrated the employment of pathos in its victorious execution.



Figure 3: IBM's Watson competing against two Jeopardy World Champions

Technology in the Academy – Can we even *get to* ethos, pathos, and logos?

As a professor of computer science, I am straddling the dilemna of allowing or forbidding the use of computers in my classroom. On the one hand, using computers to expedite note-taking, to enjoy the cornucopia of knowledge, algorithms, systems and inventions that augment and illustrate the concepts I convey are extremely useful and meaningful causes. However, technology can be a huge diversion. It can harken the epidemic addiction that Sherry Turkle speaks of when she tells us that we are connected but alone [Turkle 2012]. Technology has an addictive property that provides a temptation far too great for most of my students to resist during class. Analagous to watching television, there are educational and beneficial modalities / channels / applications for my students to use to become more engaged, and there are a host of applications and functions that take them away from the course, and the present moment. Facebooking, email, and other professors' assignments are temptations pulling them away from their colleagues and course engagement.

Technology and Definition of Self

Ramana Maharshi tells us that to query "Who am I?" is to travel through a portal to Awakening – the deepest form of self-discovery. Among other things, his question forces us to identify what we are *not*. The questions consider the possibility that technology is now stepping up to serve as another tool to shed insight on the Self. From our Facebook profile, to the "*selfie*" we take with our smartphone, technology is becoming both a window and a mirror to the Self, reflecting individual and societal mores, along with transparently presenting clues and remnants and of our daily lives, in the spirit of ethos, logos, and pathos.

Based on the fact that the technological evolution, to date, has occurred in less than one millionth the time of human evolution, examining algorithms and programs, avatars and robots, simulations and simulations of simulations, both from a humanist's point of view as well as a hands-on laboratory investigation is not just a luxury, but a necessity. This lightning speed of growth is forcing us to address what it means to be human – to identify those aspects of humanity that cannot be emulated by a machine.

Conclusion

We have seen that the embrace of technology to Aristotle's three precepts of persuasion can be accepted or rejected depending on the humans' intentions – as users, authors, students, and teachers. Yet, we have also seen that this beautiful infrastructure of ethos, logos and pathos can serve to improve our technology's ability to persuade and its overall efficacy, as well as our own.

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Academic Logos to Ethos and Pathos

Esther Zaretsky

ABSTRACT

This research paper is going to be published following Callaos (1) unique presentation and conducting a question-and-answer meeting focusing on the peer reviewing process and its inevitable ethics dilemmas. The present paper aims at presenting effective means (logic) for preserving ethics and dealing with emotions. The research focuses on investigating the contribution of logic (logos) to ethics (ethos) and emotions (pathos). The research is based on the qualitative method.

Each participant in the investigator's semester course/s received guidance on how to carry out action research and write a research report/s.

The findings show that the process advanced very fast. The participants (student teachers) were able to carry out action research in their practical work and write academic research reports. Consequently, the student teachers became aware of the impact of logic on ethics and emotions and motivated to use this method in their professional life as teachers.

1. INTRODUCTION

Definition of ethics

Ethics is a Greek word meaning "character" that is used to describe the guiding beliefs or ideals that characterize a community, nation, or ideology (2).

Callaos (1) indicated that three well known university's PhD students submitted to the conferences' organization on 2005 a bogus paper. The paper was accepted according to their CV without reviews.

According to Fried and colleagues' review (3), the first ethics code issued by the American Psychological Association (APA) (4) included research ethics as one of its major sections. In the half century since its initial publication, revisions of the APA Ethics Code have evolved to include specific standards corresponding to the ethical challenges encountered by psychologists and written into federal regulations for research protection. The most recent version of the Ethics Code includes standards comparable to the core RCR elements recommended by the National Academy of Sciences and the Office of Research Integrity (NAS, (5); ORI, (6)) including compliance with Institutional Review Boards (IRBs), informed consent, integrity in data collection and analysis, avoidance of plagiarism, honesty in dissemination of research results, protection of human participants and animal welfare, debriefing, collaboration with colleagues, and avoidance of conflicts of interest (APA (7) Fisher, 8).

2. THEORETICAL REVIEW

The present paper follows Callaos and Horne's paper (1) focusing on improving peer reviewing regarding a case study triggered by the acceptance of a bogus paper. The present situation regarding research papers sent for editing clearly requires guidance for both students and lecturers on how to

write practical and academic research articles according to the accepted ethical practices of the academic world.

The importance of ethics

Student teachers do not learn academic ethics in secondary schools and Universities. Only a few institutions give courses in this specific issue.

Fisher, Fried, Goodman and Germano (3) found that student teachers whose program had a required ethics course had more positive attitudes toward the RCR integrity of the discipline. As predicted, the closer student teachers were to receiving their doctorate and the greater the number of student teacher publications they reported, the more likely they would report they were prepared to conduct research responsibly as measured by the RCR–P.

The connection between ethos, logos and pathos

Rhetorical analysis means examining not only what authors communicate but also for what purposes they communicate their messages, what effects they attempt to evoke in readers, and how they accomplish those purposes and effects. Rhetorical analysis often involves the study of rhetorical appeals (ethos, pathos, and logos), the purposes and aims of symbolic communication, and the structure of arguments (9). Because we analyze texts that are written for particular audiences (readers in our context) for particular purposes, rhetorical analysis enhances student teachers' awareness of the salient characteristics of audiences to which authors must attend. Conducting rhetorical analysis with student teachers on newspaper articles, speeches, advertisements, and textbooks can provide important insights for them about how language works in everyday life. Other authors have written about using the analysis of literary texts similarly, in terms of helping student teachers learn the writer's craft (c.f. (10) (11)). Student teachers' reflections about this assignment a semester after completing it suggest that rhetorical analysis can begin to answer a lingering question for teachers of writing (and many other subjects): how do we help our student teachers continue to use these skills beyond the assignment for which we teach them? In other words, how do we teach writing skills that will be transferred by these teachers to their students?

This strategy has the potential to help student teachers develop the rhetorical awareness and meta-knowledge about writing that can help them transfer their knowledge of writing to new contexts and tasks.

Barrett et al. (12) surveyed about 400 postdoctoral fellows and found that only about half were aware of using authorship and publication guidelines (p. 196). They were either unaware of or disregarded publication ethics guidelines. Huth (13 & 14) examined divided and repetitive publications, which he considered to be examples of irresponsible authorship. Fox (15) suggested that publication breaches may persist due to the reluctance of reviewers or editors to take action (see also 16) Irresponsible authorship and other practices are a major problem for journal editors. For example, in the first year in his role as scientific integrity advisor for neurology, Daroff (17) found that allegations of plagiarism, theft or misappropriation of others' work, and self-plagiarism, a copyright violation (see also 18) ,were the most frequent allegations. However, Daroff (16) observed, "In no instance did we find the authors to be dishonest, but rather either sloppy, or ignorant of the 'rules'" (p. 589). In his 2007 (19) report, Daroff found that 18 of 8,664 submissions raised concerns, but only four were judged to be examples of scientific misconduct or a breach of publication ethics. He attributed these problems to "author naivety, sloppiness, and the ambiguities involved in what may constitute self-plagiarizing" (p. 1842; see also (18) (20).

Benos et al. (21) examined the publications programs of the American Physiological Society. Between 1996 and 2004, they found the following prevalence rates of publication ethics problems: redundant publications, 24%; animal welfare concerns, 16%; duplicate publications, 15%; author disputes, 14%; human welfare concerns,8%; data fabrication, 8%; plagiarism, 7%; conflicts of interest, 5%; and other (reviewer bias, submission irregularities), 3%..

Research misconduct means fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results.

(a) Fabrication is making up data or results and recording or reporting them.

(b) Falsification is manipulating research materials, equipment, or processes, or changing or omitting data or results so that the research is not accurately represented in the research record.

(c) Plagiarism is the appropriation of another person's ideas, processes, results, or words without giving appropriate credit.(d) Research misconduct does not include honest error or differences of opinion

Requirements for findings of research misconduct

A finding of research misconduct requires that

(a) there be a significant departure from accepted practices of the relevant research community; and

(b) the misconduct be committed intentionally, knowingly, or recklessly; and

(c) The allegation be proven by a preponderance of the evidence (22)

The International Committee of Medical Journal Editors (23) revised their guidelines entitled Uniform Requirements for Manuscripts Submitted to Biomedical

Journals :Writing and Editing for 3Biomedical Publication. ICMJE authorship standards. The ICMJE Uniform Requirements (23) include the central concept that "an 'author' is generally considered to be someone who has made substantive intellectual contributions to a published study"

Other ICMJE standards

The ICMJE Uniform Requirements stipulate the

(a) responsibilities of edit or peer reviewers;

(b) strategies for identifying and managing potential conflicts of interest (regarding authors' commitments, project support, editors, journal staff, and reviewers);

(c) importance of privacy and confidentiality of study participants, authors, and reviewers;

(d) rules regarding protection of human subjects and animals; and

(e) need to publish negative studies, corrections, and retractions. The ICMJE Uniform Requirements also provide practical advice about copyright, overlapping publications (duplicate, redundant, and secondary), and other matters related to publication ethics. (24). This openness is required to engage, and to be able to acknowledge the various perspectives and values of as many participants as possible in the process. The findings from the first step form the input for the next step, etc (25).

Regarding the approach of ethical learning during engineering courses, we observed the following advantages: First, we feel that the message on ethics reaches student teachers in a privileged way, since engineering student teachers observe the teacher as a senior-level engineer, and hence take him/her as a suitable professional model. In contrast, humanistic courses can be perceived as second-class courses (the institutional atmosphere may not contribute to enhancing this kind of issue) and, consequently, the impact on student teachers could be smaller.

There is much research ethics-relevant empirical data that is "hidden" from individuals seeking ethical guidance, i.e., it is not published in a traditional research ethics journal, not indexed using key words that would indicate ethics-relevant content, buried within a research article not focused on ethical issues, or not discussed in terms of its ethical implications (26).

The causes of ethics dilemmas / lack of ethics

- 1. Lack of knowledge and/or experience of writing academic articles or reports.
- 2. Copying from academic resources or Internet sites.
- 3. The need for getting an academic advanced degree via a rich publications list.

The most common ways for dealing with ethics are taking such actions as punishing students by not accepting their research reports. But the way suggested in the present paper is teaching and guiding student teachers on how to carry out action research and write reports on their own by adopting a logical structure, planning the procedure and using tools of evaluation, according to criteria of originality, innovation, appropriateness and relevance to the framework needs, the paper's significance, its quality and its presentation mode.

Objectives:

- 1. Improving the use of academic ethics while writing research reports.
- 2. Improving the students' self confidence and enhancing their motivation.
- 3. Developing the action research performance and writing academic research report abilities.

3. RESEARCH PRESENTATION

The research group was composed of 51 student teachers, majoring in regular education and special education at the same college. The research focused on the assumption that carrying out independent research would increase the quality of student teachers' writing and raise their level of professional ethics. Consequently, the student teachers' confidence while doing such activities would also be enhanced.

At the end of each course, each participant was asked to submit a research report. Each course lasted one semester. The first course was given in the first semester, and the second one in the second semester.

The research reports were based on qualitative research.

Research method

The student teachers planned their research and reported on each stage they completed. Thanks to the student teachers' personal involvement in the research process and writing of their reports, they became highly motivated in their work.

Evaluations

- 1. Comparing the student teachers' academic product levels at the beginning and end of the research course.
- 2. Comparing the pupils' achievement levels before and after carrying out the practical part and its analysis.

4. FINDINGS

It was found that the student teachers' level of achievement in promoting their pupils' progress encouraged them to write the report independently according to the guidelines laid down by the researcher.

The student teachers' academic writing level before participating in the action research was much lower than the level of their writing after participating in the field research. In their research reports, the student teachers emphasized the positive results achieved thanks to the intervention program.

Their achievements in the applied part of the research encouraged the student teachers to write their papers independently without getting any "help" from their colleagues, from the Internet or from books, and to consider every word before writing it down in order to achieve precision citing data and relating to data correctly.

Table 1: Example of Differences between the Level of Research Performance of the Student Teachers at the Beginning and Intermediate Stages of the training

Starting the Colloquium	Intermediate Data	
Focusing on theory exclusively.	Applying the theory to the practical work.	
Editing the research, in general, without using authentic examples.	Editing the research according to the standards.	
Writing long complex sentences	Formulating brief sentences.	
Lacking knowledge and experience at differentiating between the research methods and its definitions. Focusing on using E-mail exclusively.	Differentiating between the methods of research, especially quantitative and qualitative, then integrating both of them, accordingly. Communicating through online forum frequently and	
Having difficulty differentiating between main and sub objectives. Focusing on some objectives.	Focusing on the main objective and assumptions. Then defining the dependent and independent variables,	
Having difficulty formulating the assumptions. Having difficulty defining dependent and independent variables	correctly.	
Mixing results and discussion.	Differentiating between results and discussion, Summarizing each table of the results briefly, Then concentrating on the discussion and analyzing the results according to the theory.	

Case Examples

Case 1

The first case: this participant received a grade of 80 in her first semester, but she asked if she could improve her grade and improved it to 85. In the second semester, she wrote a paper in the same format but in a different discipline and received a grade of 95 without needing to make any corrections.

Case 2

When both student teachers in the group were at a high level, their combined effort was very successful in 90% of the cases.

Student teachers' feedback

"We wish to thank you for your friendly approach and your detailed guidance throughout the project. As we proceeded in our work we became aware of your very unique approach as a lecturer: precision, importance of detail, working in stages, order, planning, creativity, etc.

Undoubtedly, working on this project instilled in us good work habits and methods, and will serve us well in planning our own lesson plans/teaching activities and any other activities we might decide to work on in kindergarten.

The Internet references you chose for us provided an excellent basis for the project and proved itself in our work in kindergarten.

We will be glad to see you again next year in the additional course for which we registered, and as far as we are concerned, we can already make an appointment for a preliminary meeting."

Aspects	Lacking knowledge of ethics and of experience acting ethically.	How can authors (lecturers and student teachers) improve ethics via logic?
Academic	Copying without any connection between the contents.	There is a connection between the contents.
Social	Copying, ignoring and evading those responsible for confirming papers.	Requests for follow-up meetings and for presentations of parts of papers already prepared in all their details.
Emotional	Dissatisfaction, lack of self-confidence in writing, avoiding colleagues.	Sense of satisfaction, pride, increasing self- confidence, willingness to continue researching and writing, "we expect to continue the experience next year."

Table 2: Comparing between lacking knowledge of ethics and of experience acting ethically .and how can authors (lecturers and student teachers) improve ethics via logic?

5. DISCUSSION

The scientific importance of the research lies in the student teachers' increased ability to carry out research and write highlevel academic reports (28 & 29) The sharing of knowledge among the student teachers (30) created social interaction between them, which is necessary for accommodation with and solution of "real life" problems that appear in the real world of daily scientific work (31). This resulted in improving academic logos, ethos and pathos during the courses, while the student teachers apply the theories in their practical work. The results indicated that the logos contribute to the participants' ethos and pathos in carrying out action research, which was highly successful. The combination of theory and practice was successful too, as cited by all the student teachers in these courses "it is our first time we are learning to write according such a method which may be useful for us in our real life."

6. SUMMARY AND CONCLUSIONS

The present research indicated the contribution of logic to academic ethics and emotions of student teachers majoring in education. These results raised the level of papers submitted for review (28) and even the reviewing activity itself by the students.

The scientific importance of the research lies in the student teachers' success in carrying out action research and writing the research report (32). The student teachers' application of the theoretical materials in their practical work led them to accommodate with real life problems and look at these problems through theoretical analysis, discussion and drawing of conclusions. The student teachers who worked together in pairs raised the level of their academic writing and improved their ability to review their own academic work (28) It may be concluded that carrying out research independently and writing the related research reports can enhance the academic level of research reports and academic ethics. Furthermore, the high achievements raised the researchers' self-confidence and encouraged them to write and repeat the process thereafter.

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