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HYBRID MECHATRONICS CURRICULUM AS A MODEL FOR A HYBRID PRE-COLLEGE STEM PROGRAM

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ABSTRACT

This report presents the summary of a hybrid Robotics/Mechatronics pre-college STEM (Science, Technology, Engineering, and Mathematics) course designed to add flexibility to the lecturing process. The goal is to expand the serving capability of the LaGuardia Youth Center for Engineering Excellence (LYCEE) at LaGuardia Community College in Queens, New York City. The ultimate objective of LYCEE is to increase the enrollment of minority and female students into STEM programs and majors. The online component of the course is suggested to be about 40% of the total time of the course. High school students will share the online time between lecture in the LearnMate™ platform and live chat sessions (MSN, Skype, Yahoo Msgr., etc…) through webcam and microphone for academic discussions with faculty mentor. Some aspects about the potential application of the recommended curriculum are presented. The creation of a Hybrid STEM Lab for high schoolers is discussed.

Key words: LYCEE at LaGCC, Hybrid; Minority and female enrollment; Learning; STEM Lab; Mechatronics/Robotics; STEM enrollment

INTRODUCTION

The development of technological and scientific literacy is necessary to prepare informed citizens in the 21st century. It is believed that upcoming generations will learn first how to type rather than learning how to hand-write. Teachers and faculty have to adapt the knowledge and the way how this is imparted, in order to achieve an effective and engaging instruction. Particularly in STEM education, technology can be used to spark the interest of K-12 students and increasing the enrollment of students into STEM majors.

A way of currently attracting K-12 students into STEM experiences is the Pre-College after School STEM Labs [1-6] that are being offered in the US, with some of these centers designed to increase the STEM enrollment of minority and female population [7, 8], and others designed specifically for low-income students [9].

Diverse efforts are being conducted to invigorate the STEM education. Such works present attempts to explore STEM career options [10] at the high school level; predicting the STEM enrollment [11]; designing of more effective models to teach engineering in P-12 classrooms [12, 13]; and the analysis of the outcome of the pre-college experiences in engineering [14] as a way of assessing the effect pre-college formation in the completion of future STEM and math programs. However, these efforts might not be enough without the integration of the latest technology in communications in order to effectively engage students into STEM.

LaGuardia Youth Center for Engineering Excellence, LYCEE

Through a TITLE V funded initiative, LaGuardia CC in liaison with Vaughn College of Aeronautics have worked together on targeted, effective outreach to the Hispanic communities and feeder high schools by developing programs

and activities which increase the quality and quantity of information available to students and families regarding the opportunities in engineering related careers, as well as improve the preparedness of students wishing to pursue these opportunities. Outreach centralized activities through the newly established LYCEE Lab have provided Hispanic and other low-income high school students the opportunity to complete hands-on engineering projects with college faculty and student mentors with the potential to earn college credit. In addition, high school participants, as well as LaGCC students, are being exposed to the Vaughn College STEM Success Center and aviation/mechatronics facilities and labs through participation in College/Career Day and other bridge activities.

The current LYCEE activities which are *fully on-campus* include: semester and summer school programs focused on building engineering skills through innovative projects (robotics, mechatronics, electronics, CAD/CAM design, aeronautics, environmental, etc…); STEM-related tutoring/mentoring, professional/industry speakers; dissemination of bi-lingual information to prospective students/parents regarding requirements of opportunities in postsecondary Mechatronics. The tremendous success LYCEE has known so far is well documented and demonstrated via its website: www.laguardia.edu/lycee [8]. The LYCEE website offers information, videos, photos, and even LYCEE online application. Notwithstanding the success of LYCEE, its faculty faced the necessity of hybrid teaching and learning in order to expand the LYCEE serving capability.

Need for Hybrid STEM Pre-College Programs

Integration of teaching platforms like Blackboard Learning Systems™ to promote students learning in science [15] might not be sufficient. Adding real time interaction with instructors, leading to Hybrid learning, seems to have preference among faculty and students [16]. Based on the vast impact of Hybrid approach on education, hybrid models are being subject of study in order to identify any risk to the learning process that less face-to-face student-professor interaction might bring [17-19].

In this report, the authors propose a Hybrid Robotics/Mechatronics STEM course designed for high schoolers. The design of the hybrid Robotics/Mechatronics course proposed in this work is a response from the authors to the increase in the number of high school students applicants to LYCEE programs who have not been accepted because of space and logistic limitations. The authors expect that the implementation of such hybrid STEM model will allow the faculty to mentor more students and increase the number of students enrolled in the various LYCEE programs. The hybrid model might lead to the creation of a hybrid STEM Lab that could accept more students into the program, avoiding the risk of losing potential future STEM students.

APPROACH

The incorporation of the on-line component will be based on curriculum designed jointly by LYCEE (LaGuardia CC) Engineering Faculty and Intelitek, a company specialized in offering technical training to high school students. During the last twelve years, Intelitek has developed technology curriculum for high school students training in different STEM areas, supporting its curriculum modules on the LearnMate™ platform. The supporting platform allows students to have online access from their homes to receive tutorials, step-by-step guidance through the lessons, glossary, safety rules, help files and relevant web sites for students who want more information about a certain topic.

As for the assessment, the homeworks are designed with multiple levels of difficulty, allowing for stepped learning based on constructivist learning methods to build upon previous lessons and homeworks. The LearnMate™ platform offers a very friendly graphic-based content editor which allows teachers to customize existing material or create their own from scratch. It is remarked that due to the nature of the LYCEE Program, assessment and success of the students is not quantified by a grade, but for the completion and showcase of a final project in which students prove their understanding of the concepts by hands on experience.

In addition to the LearnMate™ platform for the academic instruction, the Robotics/Mechatronics hybrid course will complement instruction with an online chat piece: Google Talk, Skype, Meebo, Yahoo messenger, Hotmail messenger or Gmail messenger, with web camera and microphone. These live chat sessions will enable LYCEE Faculty and staff providing real time information and mentoring, expecting that the students will be more motivated to receive STEM instruction while at home. The curriculum and the

methodology of the hybrid instruction are explained below.

Mechatronics/Robotics Hybrid Curriculum

Objective: Understanding the fundamentals of mechatronic systems through hands-on projects is the best way of encouraging senior high school students to enroll in STEM majors, specifically into Mechanical, Electrical, Electronic, and Computer Science Engineering majors.

Curriculum Description: The objective of this course is to introduce participating students to general concepts of Mechatronics. Students are explained the different components of a mechatronic system: electrical, mechanical, electronic, sensors, and programming. Students are engaged at a very early stage in hands on projects in order to facilitate the learning of the concepts while on campus. The course is complemented with an online module so that students only have to spend about 60% of the time on campus. Students are encouraged to sketch and design their own robot creations, which are showcased at the end of the program after completion.

A version of a Robotics/Mechatronics hybrid curriculum designed for 13 weeks is presented in Table 1. The course is designed to use the VEX Robotics kit, proven at LYCEE Lab to be very effective for first time STEM learners to understand the concepts and assemble projects that include chassis, mechanical transmissions, microprocessor, sensors and programming. VEX Robotics kit uses EasyC as the programming language to program the microprocessor, language that is also found to be friendly and intuitive for STEM first-timers, given the graphic nature of the functions and commands.

The curriculum in Table 1 explains in detail the activities week by week, and alternates of on-campus sessions with at home instruction. Explanation of the online component is presented.

Online Interaction

From Table 1, the curriculum proposes that students spend about 45 hours on campus and 33 hours online. This is equivalent to 42% of time online. The online component combines both the time spent in the LearnMate platform and the time spent in live chatting interaction with faculty and/or LYCEE staff.

Assume a Robotics/Mechatronics project is already complete in terms of mechanical components (chassis, transmissions) assembly, power, controller and sensors, and the robot is ready to be programmed. Since the online platform LearMate supports the EasyC language, students can write the computer program from their homes. A temporary EasyC license is created for each student anytime they log in to use the program. The internet would allow students to compile and execute the program into the microprocessor of the actual robot that is on-campus.

At the same time, students are connected with LYCEE faculty/staff through chat (Yahoo messenger, Gmail messenger, etc…), and with the help of web camera students can measure the performance of the robot by uploading the program from home. From the comfort of their houses, students will be able to make changes to the program, according to the recommendations of the faculty mentor. An illustration of the online interaction concept is presented in Figure 1.

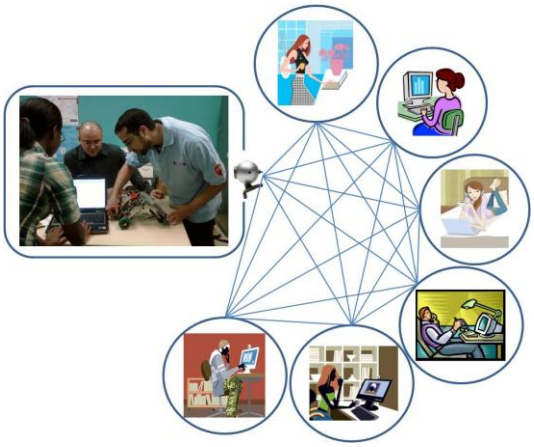

Figure 1 Illustrative concept of hybrid Robotics/Mechatronics online interaction

Figure 2 shows the interaction on-campus/online sequence as a visual add to the hybrid methodology proposed.

As a requirement for increasing the chances of success of students enrolled in the program, Hybrid LYCEE program applicants should have access to a computer with internet connection at their homes.

In the next section, the application and potential impact of the hybrid course is presented.

EXPECTED IMPACT: HYBRID LYCEE

The proposed hybrid curriculum could be applied to other STEM areas offered at the LYCEE Lab, leading to the creation of a Hybrid LYCEE Lab, H-LYCEE, which would offer

hybrid STEM formation to high schoolers in the areas:

- Mechatronics and Robotics
- Environmental
- Electricity/Electronics
- Computer Aided Design CAD/Computer Aided Manufacturing CAM/Computer Numerically Control CNC oriented to Plastics Technology
- CATIA Design

Table 1 Hybrid Robotics/Mechatronics curriculum proposed

Week	Topic	Description (brief)	On Campus Time (hrs)	At Home Time (hrs)
1	Introduction to Mechatronics	Introduction to students to the concepts and robot components: chassis, electrical, electronic, sensors, microcontroller, mechanical transmissions, programming language.	2	4
2	Project 1	Assemble the first car (same for all students): integration of mechanical and electrical components. Operating the car by remote control.	5	1
3	Physics and Robotics	Analysis of speed, velocity, angular velocity, friction, types of mechanical transmissions.	2	4
4	Introduction to Vex Programming	Block style programming for EasyC. Interface with the computer. Fundamental programming concepts: loops, statements, variables, constants, assignments, conditionals.	3	3
5	Sensors	Presentation of different type of sensors: ultrasonic range-finder, light, digital bumper, line follower, limit switch. Programming of the different sensors.	3	3
6	Final Project Assignment	Students are asked to think about their own ideas of what they would like a robot to do, taking into account the characteristics of the robotic components kit available.	3	3
7	Servo Module or Motor Module	Differences between a servo module and a motor module. When is convenient to use each of them?	3	3
8	Arms and Grippers Final Project Check-up	More examination of gear and chain and sprocket transmissions. Torque and power concepts. Gripping rage of an end effector.	3	3
9	Final Project check-up	Chassis and mechanical components check.	5	1
10	Final Project	Chassis and mechanical components check. Sensors integration.	4	2
11	Final Project	Chassis and mechanical components check. Sensors integration. Project EasyC Programming.	4	2
12	Final Project	Project EasyC programming.	4	2
13	Final project tune-up and presentation	Projects are ready to present in the end of the semester LYCEE showcase.	4	2
		Total hours: 78 = 45 On Campus **+ 33** On line	**45**	**33**

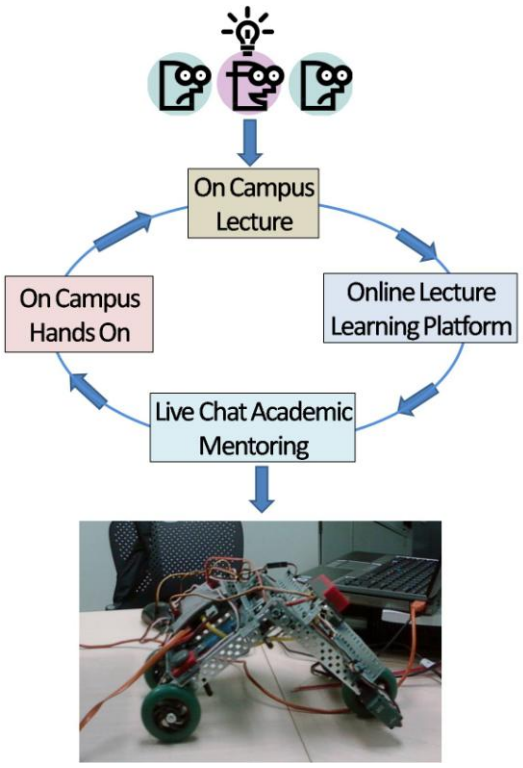

Figure 2 On campus/online interaction

The demand for LYCEE programs from high school students has increased substantially. Therefore, the need for hybrid LYCEE has become imminent. Figure 3 presents the number of students who have completed the LYCEE program since its creation Spring of 2009.

From Figure 3, it is apparent the increase in the enrollment of students in the Lab, which is a consequence of the aggressive recruitment activities performed by LYCEE. From Figure 3, we observe that from Spring 2010 term to Summer 2010 term the enrollment moved from 22 to 53 students, for an enrollment increase of 140% in comparison with the pervious term.

Moreover, during Summer 2010 term, the term with the greatest LYCEE enrollment up to the date, a total of 120 high school students applied to the LYCEE intensive summer program. Only 53 students were formally accepted into the program, indicating the potential population to be served was actually greater, where 56% of the applicants could not be served.

The success LYCEE has known over only five semesters is supported by the increasingly enrollment of students which is growing at very high rate. LYCEE would like to accommodate at least 100 students per semester. Implementing the hybrid component into all LYCEE STEM areas would allow the Lab to serve a much larger student population since the LYCEE faculty can alternate the mentoring in terms of time and space.

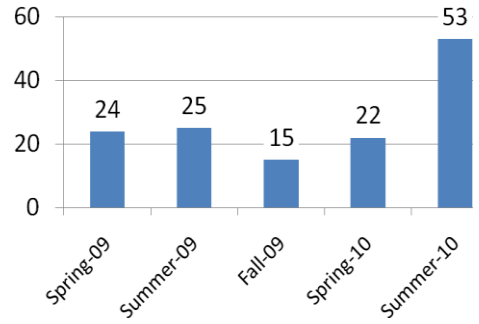

Figure 3 LYCEE enrollment per academic term

High school students participating in a hybrid STEM Lab would have to commute less time every day from their high schools, which in a city like New York City might save up to 2 hours in commuting time every day.

CONCLUSION AND FURTHER WORK

A hybrid Mechatronics/Robotics curriculum course for STEM pre-college students was presented in this report. The course proposes students to spend about 40% of the time online. The online time includes not only instruction at an academic platform but also chat interaction (MSN Messenger, Skype, Yahoo chat, etc…) of students and faculty. Students would be able of programming a real robot from home and engage in academic discussions with teammates and faculty mentors through webcams and microphones.

The hybrid model can be extended to other STEM areas leading to a more comprehensive STEM Lab, the Hybrid LYCEE, which would facilitate the instruction and accommodate more high schoolers per term. This would favor the potential enrollment of participating students into STEM majors.

The Hybrid LYCEE program could also incorporate a post-program following up of the students, in order to estimate what percentage of students who participated in the program did actually enroll into STEM majors.

Another future work derived from this report is the submission of a Hybrid LYCEE proposal to serve New York City students at LaGuardia Community College in Queens.

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