Research-based teaching in science education: A regional innovative program

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ABSTRACT

There is a tremendous need to transition from teaching science focused upon teacher lectures to teaching that puts the student and the learning process in the center by active scientific experimentation. Teaching using the research approach encourages cooperative learning in problem solving through which the student gains experience with formulating questions, constructing a set of experiments, gathering data and drawing conclusions. The research-based teaching approach is conceived as the right method to foster STEM educated population (STEM refers to science, technology, engineering, and math). A high-quality STEM-oriented education is essential for gaining the intellectual tools to integrate successfully into society and workforce. The initiative’s goal: to increase substantially the number of high school graduates with the type and level of educational achievements in STEM that will enable them to pursue a science degree on the way to gaining employment in a scientific or technological industry. The application of teaching that is based on the research approach raises many limitations among teachers. Therefore, a unique regional innovative program was established in order to increases teachers’ self-confidence in carrying out the process. An exceptional coalition of stakeholders was formed: Academic colleges; research institutes; local industries; municipalities’ educational leaders; the Ministry of Education, and schools. This initiative constitutes a special cooperative effort with all partners guided by the same goal and measured against the same objectives in order to attain a regional impact. The purpose of this paper is to investigate the action process for improving implementation and to evaluate reaching its’ goals.

Keywords: Science education, Inquiry-based learning, Assessment, Problem-based learning, Cooperative model, Regional approach

INTRODUCTION

The inquiry-based approach is an important pedagogical approach for instilling scientific knowledge. There is a tremendous need to transition from teaching science focused upon teacher lectures to teaching that puts the student in the center and that invites active, investigative scientific experimentation. Teaching using the investigative approach encourages cooperative learning through which the student gains experience with formulating questions, constructing a set of experiments, gathering data and drawing conclusions. Research skills include the ability to think in diverse ways, develop creativity and independence in learning, awaken curiosity and wonder, develop generally positive attitudes towards learning and contributes to improving scholastic achievements (Haury, 1993; Kühne, 1995; Shulman & Tamir, 1973). The inquiry-based teaching method is based on the constructivist approach which views learning as an active process that constructs meanings in the learners’ minds. Learning environments that are based on this approach were found particularly beneficial to students by enhancing their learning processes (Rivet & Krajcik, 2004; Rosenfeld & Rosenfeld, 2006; Dori & Sasson, 2008; Von Glaserfeld, 1991). The application of inquiry-based teaching in science classes raises many limitations among teachers. Therefore, it is important to build a training framework for professional development that increases their self-confidence in carrying out the process. Deep pedagogical change is possible only by creating active involvement of science teachers who, themselves, experiment with applicable scientific inquiry together with the support of experts: "Teachers must begin to engage in practices that have built-in support for the changes they have made; otherwise, the changes are likely to erode over time” (Franke, Carpenter, Fennema, Ansell & Behrend 1998, p. 67).

For the last few years, the 15 municipalities of the East Galilee in Israel have joined together in a forum to advance processes and initiatives outside of their local frameworks in order to gain the benefits of operating on a regional level. One of the main educational goals is to foster STEM educated population (STEM refers to science, technology, engineering, and math). A high-quality STEM-oriented education is essential for gaining the intellectual tools to integrate successfully into society and workforce. Increased opportunities in STEM education among schoolchildren will lead more of them to attain an academic science degree. The initiative’s goal: to increase substantially the number of high school graduates from the eastern Galilee with the type and level of educational achievements in STEM that will enable them to pursue a science degree on the way to gaining employment in a scientific or technological industry. The formation of an exceptional coalition of stakeholders
from the region, from all sectors associated with achieving the goal is crucial. Principal stakeholders include: 15 municipalities educational leaders; the colleges in the region which teach science and technology subjects; research institutes in the region; a number of local industries; the Ministry of Education, schools principals and science teachers.

The regional science initiative includes special programs for both science teachers and students which embedded a significant involvement of academy, research and industry experts. Physical infrastructure including research laboratories, equipment and materials are used in favor of the regional education system therefore advanced science exploration processes become possible. The regional innovative program promotes the establishment of cooperation between the higher education and high schools in the area and encourages educational continuity, with an emphasis on science education.

This initiative constitutes a special cooperative effort with all partners guided by the same goal and measured against the same objectives in order to attain a regional impact. Regionality is a principle of operation according to which a number of partners in one region work together. The principle has significant advantages for initiatives, operation and application of processes, enterprises and projects with expansive vision.

Regionality rests upon existing area assets and strengths, with the goal of building them into sustainable platforms for change (Kania & Kramer, 2011).

Based on Kania and Kramer (2011) recommendation for developing a shared system of measurement for collecting data and measuring results consistently across all participants an evaluation research was conducted. Evaluation describes educational processes and judges their value by means of relevant criteria. It is the process that determines the measure of achievement of educational goals. Evaluation of educational programs includes the use of measurement methods designed with the goal of improving the programs through a process of goal and objective clarification, development of a rationale and indices of implementation and increasing the awareness and understanding among participants (Smith, 1989; Trevisan, 2007).

RESEARCH SETTINGS

The goal of this paper was to investigate the effectiveness of the program. The research question that was raised: How does the program influence the development of skills and scientific thinking among students?

The research tool for investigating students' thinking skills was case-based questionnaire. Case study is a learning tool presented in a narrative way that deals with a real situations. Case studies are viewed as contributors to professional development, usually used as a discipline-based teaching method. The use of case studies features several themes: cases as a tool for professional preparation and development, cases for facilitating critical thinking and exploring dilemmas, and cases as an assessment tool (Dori, 2003; Dori & Herscovitz, 1999, 2005; Dori & Sasson, 2008; Kobballa & Tippins, 2000; Sasson & Dori, 2011; Tal & Hochberg, 2003; Tobin, Kahle, & Fraser, 1990). Pre and post case-based questionnaires were designed to assess a host of thinking skills, including inquiry, graphing, and argumentation. The questionnaires included a variety of assignments for assessing these thinking skills.

In the inquiry assignment students were asked to formulate a research question, based on the scientific text, and to define its' variables (dependent and independent). In the graphic assignment they were asked to describe the graphs and to analyze data and conclude logical conclusions. The argumentation assignment tested students' ability to present a scientific claim based on relevant explanations and examples. For each assignment, an assessment rubric was conducted and validated by five experts in science education achieving 90% interraters reliability. Table 1 presents an example of one of the rubrics that was used to assess students' ability to formulate a research question, based on the scientific text, and to define its' variables.

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No answer; inquiry question is not relevant or not presenting the right structure – effect of variable A on B</td>
</tr>
<tr>
<td>1</td>
<td>The inquiry question is relevant to the scientific text and presents the right structure – effect of variable A on B or the question presents innovative aspect that wasn’t presented directly by the scientific text</td>
</tr>
<tr>
<td>2</td>
<td>The inquiry question is relevant to the scientific text and presents the right structure – effect of variable A on B and the question presents innovative aspect that wasn’t presented directly by the scientific text</td>
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</table>

About 150 junior high school students answered the questionnaires. 47% girls, 50% boys and 3% didn’t mention their gender. The students participated in a science program that included about 50 academic hours. During the program the students were exposed to the science topic, experienced lab activities using special analytic methods, and conducted a research in small groups.

FINDINGS

Based on the rubrics that were developed students’ responses were assessed and the scores were calculated for each thinking skill. Table 2 represents students’ scores in the thinking skills that were assessed.
The results indicate on a significant improvement in the students' thinking skills. The scientific program students significantly improved their ability to ask research questions based on reading scientific text, to describe and analyze research results that are presented graphically and to claim arguments based on scientific knowledge.

**DISCUSSION**

The purpose of this paper was to demonstrate investigation of the action process of a unique regional innovative program that was established in order to promote scientific research.

Social responsibility reflects the commitment of the organizations to contribute to the development of the communities in the region. Organizations, such as higher-education and research institutes and industries recognize that their success as an organization depends also on the quality of the life in the nearby communities. This conception created value to the organization and its stakeholders through social and educational opportunities (Geryk, 2012; Shamir, 2002). Assessment culture that includes research on the educational work also reflects social responsibility to explain the conducting methods and to take responsibility for the consequences.

In science education, learning environments that incorporate an inquiry-based approach or case studies are recognized as fostering students’ thinking skills (Lee & Thompson 1997; Lohman 2002; Muthukrishna & Borkowski 1995; Sasson & Dori, 2006). In this paper, the focus was on assessing science thinking skills by case studies. Students significantly improved their ability to ask research questions based on reading scientific text, to describe and analyze research results that are presented graphically and to claim arguments based on scientific knowledge. The study is likely to provide deeper understanding of the nature of student achievements in the field of science.

In educational theory, a contribution is expected to the general body of knowledge dealing with evaluation in education and, more specifically, in researching the relation between opportunities for learning and results. With regard to practice, it is expected to gain a broad understanding of supplemental science programs operating in a wide geographical area and their contribution toward advancing the science achievements of students.

In recent years, there has been a considerable decrease in the number of students choosing to study the fields of science and technology in high school and university. In addition, the scores of Israeli students on international tests are relatively low and demonstrate low scientific adeptness and only partial command of the skills of scientific thinking. The findings of this study, that relate to the development of scientific skills among students, can contribute to the advancement of science studies in Israel.

**REFERENCES**


