AC 2010-318: A MODEL FOR PROMOTING COGNITION, META-COGNITION AND MOTIVATION

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A Model for Promoting Cognition, Metacognition and Motivation in the Technological Class: The Theory of Self-Regulated Learning

Abstract

Educators widely acknowledge the advantages of project-based learning in technology and engineering over traditional schooling. However, teachers with a strong background in engineering often focus on learning specific subject matter and completing a technical work rather than developing students' learning competences. To address this situation, it is suggested to adapt the theory of self-regulated learning to the context of technology education, with a focus on promoting cognition, metacognition and motivation in the class. The guidelines for adapting this model for a reform in technology education in Israeli high schools, and preliminary outcomes from delivering an in-service course to teachers are discussed.

Introduction

Educators are increasingly aware that one of the main objectives of education is to foster students' general skills such as problem-solving, creativity and teamwork. To achieve this end, schooling must shift to more student-centered instruction such as project-based learning as a substitute for traditional teaching methods. On the one hand, several studies in Israel and other countries emphasize the educational advantages of the project method in fostering meaningful learning and raising students' motivation [1] [2] [3]. On the other hand, teachers having a strong engineering background frequently center on teaching specific subject matter, while the development of higher intellectual skills is often perceived as a side-effect or 'natural outcome' of learning scientific-related subjects. As a result, students might prepare very sophisticated projects from a technical viewpoint but progress only little in terms of becoming independent learners and creative designers. In order to maximize the educational potential of technology education in developing students' learning competences, we propose a model for adapting the theory of self-regulated learning to the context of technology education (SRLT) [4], as described below. Preliminary outcomes from using this model as a framework for a reform in teaching technology in Israeli high schools are also discussed.

Fostering Self-Regulated Learning in Technology education (SRLT)

Zimmerman and Schunk [5] define self-regulated learning as self-generated thoughts, feelings and actions that are systematically oriented toward the attainment of students' own goals. Zimmerman and Camplio [6] show that the self-regulated learning theory is closely related to fostering individuals' problem-solving competency. The SRLT model consists of three major dimensions, as described below.

The cognitive dimension relates to the conscious mental processes by which people accumulate and construct knowledge. It is common to distinguish between lower-level cognitive processes, such as perceiving, recognizing, memorizing, understanding and conceiving, and higher-level mental functions, such as analyzing, conclusion drawing, reasoning, synthesizing, problem-solving, assessing and creative thinking. Cognition is also about educators understanding that learning occurs through social interaction, as well as interaction with the physical world such as artifacts or computers.

The **metacognitive** dimension of the SRLT has to do with individuals' awareness of their learning, and their ability to monitor or control any aspect of cognition, for example, memory, attention, communication, learning, or problem-solving. Metacognition is also about learners' ability to set goals, consider the nature of a task and reflect on their learning [7]. In the context of technology education, successful learning also involves the intentional use of strategies, techniques or heuristics that can help in the process of problem-solving and invention.

The **motivational** aspect of SRLT refers to students' intrinsic satisfaction from being engaged in challenging assignments and their self-efficacy beliefs about their ability to accomplish a task [8]. According to Bandura's [9] socio-cognitive theory, self-efficacy beliefs are determined by previous positive experience in similar tasks and the existence of a supportive social and emotional environment.

Using self-regulated learning in technology (SRLT) as a framework for fostering technology education in Israeli high schools

The self-regulated learning in technology education (SRLT) model described above has been adopted as the main conceptual framework for reform in technology education instruction in Israeli high schools. In our country, about one third of high school students major in technology. These students learn advanced courses in areas such as electricity, electronics, mechanical engineering and computer sciences. In the field of electricity and electronics, about half of the 12th grade students prepare a graduating project in subjects such as control systems, communication systems and robotics, as illustrated in Figure 1.

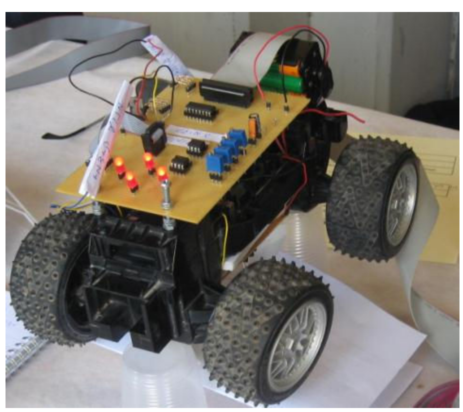

Figure 1: A robot constructed by high school students as a graduating project in technology education.

To construct a robot, such as the example presented in Figure 1, the students have to deal with issues such as mechanics, electronic circuits, sensors and programming. The students work on their projects individually or in pairs during the school year. They have to prepare a booklet including all the information about the system's design and construction, and attend a final oral exam on their projects. It is important to note that the project work replaces a conventional pencil-and paper matriculation exam.

A need for change

One the one hand, educators consider project-based learning as one of the best instructional approaches aimed at fostering students' motivation and developing higher-order thinking skills such as problem-solving and creativity. On the other hand, teachers with a background in engineering frequently regard projects as a means of teaching subject matter and imparting practical experience in the profession to the students. These teachers often regard the completion of technical work as the major objective of technology projects but lack the pedagogical knowledge necessary to developing students' higher cognitive and personal competences, such as independent learning and problem-solving. As already noted, many technology teachers perceive enhancing these skills as a natural outcome of teaching specific knowledge, for example, physics, electronics and computing [10]. This was the background for the program addressed in this paper, which takes place as collaboration between a team from Ben-Gurion University of the Negev and a team headed by the Chief Inspector for teaching electricity and electronics from the Ministry of Education.

A reform in project-based learning in technological classes

The main components of this program are:

1) Providing an in-service training course (28 hours) to teachers in the country's center, south and north (a total of 160 teachers).
2) Developing new guidelines for students and teachers for preparing projects in electricity and electronics based on principles of the SRLT model mentioned above.
3) Introducing gradual changes in formal requirements for students' project work and the oral exams each student attends upon finishing his/her project.

Following are the main topics included in the teachers' in-service course:

1. The need to focus technology education on developing higher-order intellectual skills rather than on teaching a huge amount of subject matter.
2. Types of knowledge in science and technology: declarative knowledge, procedural knowledge, conceptual knowledge and qualitative knowledge in technology.
3. A problem-solving taxonomy (PST) in technology and engineering. This taxonomy, which was developed by Plants et al. [11] in the context of engineering education, consists of the following five levels: routine, diagnosis, strategy, application and creativity.
4. The role of technological projects in enhancing higher-order learning skills;
5. The use of e-portfolios as a means of documenting project work and reflection by the students. For example, it is proposed that each student construct a personal website in which he/she presents the entire process of the system's design, construction, troubleshooting and improvement.

What does the SRLT model add to the project-work in schools?

Following are some guidelines that have been stressed in the teachers' course as well as in the new formal requirements for preparing projects in schools:

1. The main objective of the projects is to foster students' learning competences, such as inquiry, problem-solving and troubleshooting, rather than learning more theory or handling technical issues. Consequently, schools are allowed to reduce the size or complexity level of the systems the students design in comparison to the past.
2. Students should document all their work on the project, for example, inquiry into the problem, the system's conceptual design, initial planning sketches, construction stages, troubleshooting and improvement.
3. Students are encouraged to use the e-portfolio method in the form of a personal website to document the entire system development process. This approach substitutes the traditional method, according to which students prepare a summative booklet on their project, including technical information only such as electronic circuits or computer programs.
4. Teachers will guide the students to reflect periodically on their work by writing down their thoughts before, during and after handling each project stage, for example, their interest, motivation and self-confidence about accomplishing the task.

The above guidelines demonstrate how the cognitive, metacognitive and motivational dimensions of the SRLT model were incorporated into schooling. It must be emphasized that this approach differs significantly from the project work in engineering-oriented classes, since many teachers essentially stress learning the subject matter and completing the technical work. This point was expressed in the teachers' responses to the current program, as seen in the following section.

Preliminary findings

As part of the research, we documented and videotaped almost fully the sessions in three classes, including, for instance, discussions held in the class and informal conversations with teachers. In addition, all of the participants filled out three feedback questionnaires on specific issues raised in the class and a summative questionnaire at the end of the course.

Throughout the course and in the summative discussion, the teachers had the following comments:

"This was the first time I participated in a teacher training course and we were not taught new topics in electronics and computers."

"I had never heard things like what was discussed in this course."

"Now I understand that most of the time I have been teaching declarative or procedural knowledge."

"I will use the presentation from this course to explain to the school's principal, the parents and the students themselves how electronics studies help in developing *thinking."*

Generally, the teachers in all three groups responded very positively to the course and to the proposed reform in project work in schools. For example, Figure 2 illustrates that the participants supported the notion of shifting the focus of project work to developing students' cognitive skills and self-efficacy beliefs rather than on teaching extensive subject matter, as discussed in the course. Figure 3 shows that the participants acknowledged the idea that students use e-portfolios as a means of documenting and reflecting on the project work, instead of preparing a conventional printed booklet on the project.

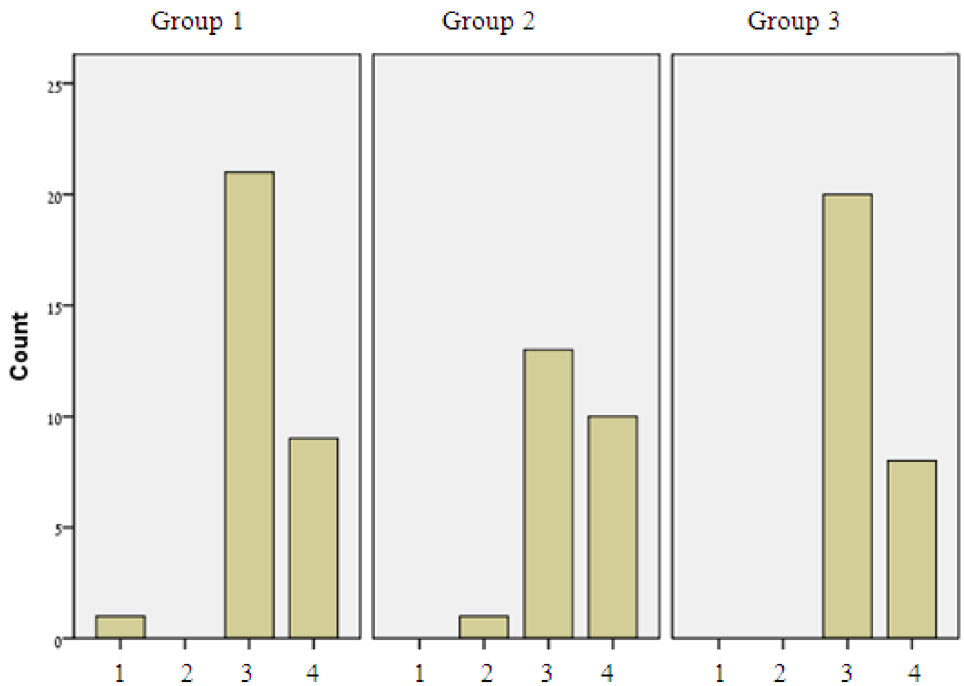

Figure 2: Teachers' views about fostering higher-order thinking in technological projects rather than teaching extensive subject matter (1=very low; 2=low; 3=high; 4=very high).

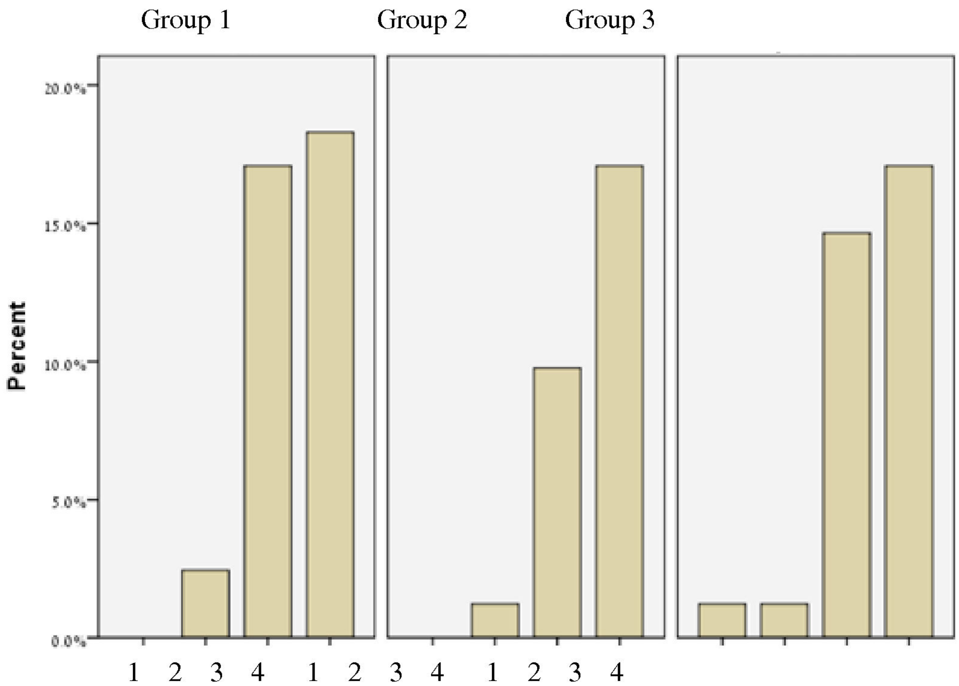

Figure 3: Teachers' attitudes regarding using e-portfolios for documenting a project's design and construction (1=very low; 2=low; 3=high; 4=very high).

One can see that the teachers in all three groups expressed high or very high support for the ideas presented to them in the course. Moreover, some teachers started to implement the proposed changes in project work in their classes already during the course, and reported these points to their colleagues. For example, one of the participants in the course, an electronics teacher who also serves as a part-time supervisor, took the photo seen in Figure 4 in his school and displayed it in the teachers' course.

Figure 4: A student documenting electronically the testing of an electronic circuit in his project.

The teacher suggested that requiring students to present and explain the different stages of their project work is likely to increase their responsibility for the assignment and to encourage them to reflect on their learning. Another teacher reported that she had asked several students in her class to prepare a website on their project. She showed how one of the students described his project and reflected on his work, and summarized that this change contributed greatly to increasing students' interest and motivation in the class.

Concluding remarks

This paper addresses an effort to impart to technology teachers the pedagogical knowledge necessary for fostering students' cognitive, metacognitive and motivational competences derived from the Self-Regulated Learning in Technology education (SRLT) model. The current findings indicate that technology educators accept and support the proposed reform. We feel that collaboration between university experts, the teachers and Ministry of Education supervisors has been a key factor in achieving the desired goals.

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