עבודת גמר (תזה) לתואר
דוקטור לפילוסופיה

מוגשת למועצה המדעית של
מכון ויצמן למדע
רחובות, ישראל

Thesis for the degree
Doctor of Philosophy

Submitted to the Scientific Council of the
Weizmann Institute of Science
Rehovot, Israel

מאת
צבי אריכא

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"פיזיקה ותעשייה": פיתוח ומחקר של מודל לקידום מצוינות באוכלוסיות תת-משיגות

"Physics & Industry": Development and Study of a Model for Promoting Excellence among Under-Achieving Students

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July, 2013

Abstract

The Purpose of the Work

The "Physics & Industry" program implemented at the Weizmann Institute of Science for the last decade aims to promote excellence among high-school students specializing in Physics. Six years ago the program was introduced to the "Etgar high school" students who study in the technological track. "Etgar high school" includes a large number of under-achievers and students with learning disabilities. Like other culturally disadvantaged populations, these students have deficits in knowledge, practices, self-image and Self-Regulating Learning (SRL) skills. Beside the traditional goals of "Physics and Industry" program we aimed to promote unique goals for this population, for example: developing work habits and self-regulation in learning. Therefore, a central objective of this work was to develop a teaching approach to achieve these goals in addition to the traditional goals of the program.

This report describes the design of implementing "Physics and Industry" among under-achieving students and the associated research carried out during one two-year cycle (September 2007- July 2009). The study aimed to examine ways in which one can promote these students by using methods that challenge them and provide at the same time systematic tools for dealing with these challenges. The study examined the achievement of the program's goals in this population; characterized the processes of learning and guidance in the program and how they relate to developing self-efficacy and self-regulation of learning skills.

The "Physics & Industry" Program and the Instructional Approach

"Physics & Industry" is a two-year Project Based Learning program (PBL) which takes place in the Davidson Institute of Science Education at the Weizmann Institute of Science. The program, carried out in "regional classes", provides the students 40% of their matriculation credit in physics. The purpose of the program is expanding physics knowledge and developing skills in areas that are not offered in regular high-school physics classes such as; experiencing research of an authentic problem relevant to High-Tech industry; developing project and design skills; developing creative thinking and introduction to the world of the high-tech industry. Pairs of students design a functional artifact (e.g. an electro-optics'-based cane for the blind) which relates to an authentic

technological challenging problem. The students are tutored by expert physics teachers and High-Tech engineers.

The program is extra-curricular and is offered to high achieving and interested students who attend regular schools and are interested in dealing with contemporary issues an opportunity offered by unique schools – broadening the scale of the students skills and talents.

The students in the "regional classes" arrive from several school in the vicinity of the Weizmann Institute and attend the class for a period of 18 months, once every two weeks for four hours, beginning in the 11th grade and finish in the 12 grade. This differs from the program for "Etgar High School". The students from this school arrive as a whole class, focusing on the class which excels academically, and attend the program for two years, once a week for three hours.

The teaching approach adopted for this population was based on the notion that challenging learners in a supportive environment, which provides a "safety net", has the potential to assist them in demonstrating their abilities (Treisman, 1992, Doppelt, 2000). Therefore, for example, the program incorporates intervention methods developed by Zimmerman (Zimmerman, 1996, 2004) to encourage self-regulation in learning. That based on the findings in the literature (Perry et al, 2002) showing that when one incorporates these methods in teaching, disadvantaged students become self-efficient and do not avoid dealing with challenges. The teaching approach for these students was also influenced by the "rehabilitate teaching" approach of Frankenstein (1971, 1987) and offered challenges, such as those described by Doppelt (2000).

The Research

The research questions:

1. What were the learning and guidance processes in the "Physics & Industry" program for the "Etgar high school" students? In particular:
    1.1 How did self-regulation develop in students' learning?
    1.2 What are the characteristics of the guidance processes in the program?
    1.3 What are the learning and guidance patterns in the program?
2. What were the outcomes of students' learning in the program? In:
    2.1 Self-regulation in learning.

2.2 Students' perception of their self-efficacy.

2.3 Attainment of competencies required for carrying our projects and solving ill-defined problems.

To gather data on the aforementioned issues I have followed the program as one of its facilitators, and observed the activities of students and facilitators, for more than 60 meetings, once a week for two years (each encounter lasted three hours). In addition, I examined some of the students, interviewed most of them and interviewed some teachers and facilitators who accompanied them at the Weizmann Institute. I have accumulated over 250 hours of recording. The present study exploited some of this data. The analysis focused on key meetings along the program and what happened between them. Case studies of two pairs of students and four guides were carried out. The guides consisted of two expert teachers, a laboratory technician and a teaching assistant. Additional research instruments included a researcher diary, questionnaires (to all students) and a summary activity to the case study students.

To analyze the behavior of the students and their progress during their participation in the program, analysis frameworks were needed. It turned vital especially after I performed preliminary analysis of the data gathered from running the first pilot cycle of the program during one year before the main research started.

The attempt to analyze the wealth of events that occurred during students' work, especially those that occurred during construction projects, led me to seek relevant theoretical frameworks. The "Pintrich model framework" (Pintrich, 2000, 2003), designed for analyzing aspects of Self-Regulated Learning, was selected. In attempting to use it and develop reliable coding for analyzing students' work I found myself sharpening this framework as well using it to enrich and adapt the Knowledge Integration (KI) framework (Linn & Eylon, 2006, 2011) for analyzing the facilitators' guidance. I also introduced some changes in the SRL framework for analyzing the interviews. Overall I developed three interrelated analysis frameworks that constitute the major tools of the analysis methodology. In addition I carried out content analysis of the researcher diary and the final task, and a statistical analysis of the student questionnaires.

Therefore, the research has two purposes: First, the original main goal of the research as described above, to present key findings that arise when the program "Physics and Industry" is implemented among under-achieving students. Second, developed with the research, is to demonstrate the use of frameworks for which I analyzed the behavior of the students and tutors methods of guidance in the program.

The Main Conclusions

Several main conclusions emerge from the analysis of the data gathered during the program. The students found the program challenging and claimed that their self-efficacy was high and that they have the ability to control their achievements. This correlates with the impression of the external examiners who have tested the students. However, the program facilitators had a different view: they claimed that the students did not have enough motivation and that their competence was low. Nevertheless, they admitted that the skills of the students at the end of the program were much higher than those in the beginning.

The detailed analysis of the processes taking place during the program refers to the gap between students' perceptions and those of the facilitators. The following are two interpretations of this gap: 1. this gap is expected a-priori: at the end of the program students speak the "program language" and know how to say the "right words". Consequently, the self-reports and the impressions of external viewers (such as the examiners) are not consistent with the perceptions of their instructors who know the "real level" of the students. 2. The gap between perceptions can be explained when examining the processes that occur in the program. Throughout the program students are required to put in effort and their performance, analyzed with objective tools, is low. However, in comparison with their abilities at the beginning – or in the words of one of the facilitators: "The Delta" – the improvement is great. This is agreed upon by both the facilitators and the students, and thus the sense of success by the students is great, even if the facilitators expect a greater delta.

Additional central conclusions derived from the research refer to the instructional method in the program. Based on the detailed analysis of the instruction methods, the expert teachers promote students skills to a larger extent than the engineers. Apparently, the expert teachers often demand from the students to express their knowledge and then

reflect it back to them until the students understand by themselves the challenge they are facing, whereas the engineers are too hasty to offer the students easy solutions to the challenges they deal with.

Another important conclusion emerging from the study is that the success of the program is dependent upon the support provided during the program which is tailored to the specific needs of the population. Moreover, throughout the program, the facilitators consciously keep a gap between the challenge they present to the students and the support given. It appears that this gap actually encourages the students since they feel that the staff believes in their abilities. Consequently, some of them construct projects that are as sophisticated as the projects built by "regional class" students.