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Implementation and Assessment of Project-Based Learning in a Flexible Environment

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ABSTRACT: Project-based learning (PBL) is a well-known method for imparting thinking competencies and creating flexible learning environments. Advancing low-achieving pupils is an on-going challenge for educational systems. Routing low-achievers into low-learning tracks creates a vicious circle. In order to extract pupils and their teachers from the on-going cycle of failure, and to promote pupils cognitively and emotionally, four steps were taken: defining significant goals for the pupils as well as for the teachers, changing the learning environment, carrying out original projects taking advantage of the pupils' special skills and abilities, and changing assessment methods for project-based learning activities in a computerized environment.

This paper presents a continuous field research that has used qualitative and quantitative tools for exploring pupils' progress in the affective and the cognitive domains. The research tools were: Analysis of pupils' portfolios, observations of class activities, interviews with pupils, teachers and school management, achievements in the matriculation examinations, and assessment of pupils' projects.

The findings indicate that scientific-technological PBL elevated pupils' motivation and self-image at all levels and achieved significant affective learning. The activities over three years are summarized and show an increase in the number of students achieving the college admittance requirements. Most of the low-achieving pupils succeeded with distinction in the same matriculation exams that the high-achievers did in the same school.

Keywords: learning environment, low-achieving pupils, project-based learning, technology education

INTRODUCTION

Project-based learning (PBL) is a well-known method for imparting thinking competencies and creating flexible learning environments. The educational system usually directs talented pupils to extra-curricular programs in order to foster learning and develop thinking competencies (Barak 2002). It is rare to find schools that aim to advance the thinking competencies and foster the learning of low-achieving pupils.

This paper will tell the story of 54 pupils who were low-achievers at junior high school and were routed by their school towards low-learning tracks. The intervention program has set new goals for the school management, teachers, and the pupils themselves. The goals were divided into three domains: first, to raise teachers' and pupils' self-image and motivation. The second goal is to change the learning environment by changing teaching methods and applying PBL in modern and computerized laboratories. The third goal is to advance pupils towards success in the national matriculation examinations that every pupil in Israel takes in the 10th, 11th, and 12th grades.

In the first domain, the findings show that all five schools that have participated in the program changed their attitude towards promoting low-achieving pupils. In the second domain, the schools invested more resources in the education of these pupils: they engaged better teachers to teach Math, English and Literature in these classes. The technology teachers participated in an extended in-service workshop in order to implement PBL in classes. They took an active part in a special summer camp aimed at fostering PBL with their pupils. In the third domain the schools prepared these pupils towards the regular matriculation examinations. Passing the examinations in three technological subjects, and in Math, English and Literature, fulfills the precondition for admission to further education in Israel. In one school there was 100% percent success in the examination in electrical systems that is taken in the 12th grade. Pupils who were low-achievers at the beginning of high school attained higher scores than the high-achievers who studied the same subject at a higher level.

This study strengthens the belief that low-achievers can be advanced toward success and better integration into the educated and modern society of the third millennium. Educational systems should invest more resources in order to advance low-achievers. The better the teacher who teaches these classes, the further these pupils will advance. PBL was shown to be an exciting method to promote these pupils' learning, motivation and self-image, and greater success in the matriculation examinations.

THEORETICAL BACKGROUND

Active learning is an educational approach that puts the pupils at the center of the learning process and recognizes the variance between different learning styles (Dewey 1916; Gardner 1993; Kolb 1985; Perkins 1992; Sternberg & Grigorenko 1995). The common denominator in these educational theories is the emphasis placed on the activities of the individual learner that motivate learning processes that occur inside the pupil's mind and for which he/she is responsible. Rogers (1969) and Holt (1965) claim that schools should allow pupils to satisfy their curiosity, and develop their skills and abilities, as they will. Pupils will not reach true learning in school if the school continues to decide for the pupils what and how to learn. Active learning transfers the responsibility of the learning from the teacher to the pupil. Rogers (1969), and Papert (1980), see it as an important educational goal. The transfer of responsibility should occur through the teacher who gives many degrees of freedom for learning and changes the teacher's role from that of lecturer to the role of tutor, a guide, and a partner in the learning process (Barth 1972). The knowledge gained through active learning is constructive knowledge from active thinking and problem solving, and is not knowledge of memorizing and doing exercises for the teachers or doing homework from books (Gardner 1991).

Piaget (1969) described the pupil as a scientist who tries to understand the world through meaningful learning as an activity of constructing ideas and not as a process of memorizing information. Nevertheless, schools continue to test pupils on their ability to recall memorized procedures and information. Schools continue to examine skills that are the least important to life (Sternberg 1998). Learning is a process of constructing knowledge in the pupil's mind. Creating an engineering prototype such as in this study, in real world situations supports the constructionist theory (Papert 1991). Project-based learning has a nature of exploring new areas, discovering new scientific issues and integrating knowledge from different subjects (Barak & Raz 1998; Barak & Doppelt 2000). Computerized technological systems provide a rich learning environment and expose the learner to a variety of representations and configurations, such as: true model, simulation, building models that represent formulas, algorithms, graphics and animation. One of the better-known examples of such a rich computerized learning environment is the LEGO-Logo system (Kromholtz 1998; Jarvinen 1998; Jarvela 1995). Resnick and Ocko (1991) state that this learning environment puts children in control since they formulate their own designs and experiments, and work on projects that they care about personally, instead of recreating someone else's experiment. Project based learning in technology encourages students to work in teams (Barak & Maymon 1998; Denton 1994). In this way, students combine 'hands-on' activities with what Papert (1980) has termed 'heads-in' activities. Learning environments such as LEGO/Logo enable the construction of concepts in the learner's mind (Resnick & Ocko 1991). When pupils create projects, they experience meaningful study that enables the exercising of sophisticated ideas that arise from their own projects (Doppelt & Barak 2002). Experiencing learning within a high-tech modern engineering environment contributes to the pupils' self-image and their motivation to succeed in their studies (Barak et al. 1997).

These educational approaches are important for the development of all pupils, but they are essential for the low-achievers that have difficulties with traditional teaching methods. Advancing low-achieving pupils is an on-going challenge for educational systems. Routing low-achievers into low-learning tracks creates a vicious circle. The school system has low expectations of the pupils; the pupils accumulate a history of failure; and the teachers emerge as having low self-esteem and low professional image (Barak et al. 1994). These pupils require attractive learning material that relate to their real world and answer their needs.

Over the past two decades, educational research has been concerned with the contribution of a rich learning environment in the attainment of educational goals, such as improvement in learning achievements and attitudes towards studies and school (Fraser 1998; Fraser et al. 1995; Fraser &

Tobin 1991). The association of science and technology studies with a rich, flexible, computer-embedded learning environment may enable the advancement of pupils in attaining higher academic achievements, and overcoming their cognitive and affective difficulties (Barak et al. 2000).

Educational researchers have become aware that the learning environment must engage the learner in activities that relate to the world outside school. A rich, flexible learning environment is necessary for accelerating the learning of at-risk pupils (Levin 1992). A pupil who is given the opportunity to create a prototype deals with designing, making and evaluating. Through such experiences he/she realizes that much depends on him/herself. Consequently he/she may gain self-esteem and personal responsibility (Waks 1995).

THE INTERVENTION PROGRAM

Israeli high-school pupils study general subjects such as Math, English, Literature, and History. In addition they have to choose one or more subjects as a major. They can choose major subjects from the Humanities or from the Science and Technology Curricula. There are various subjects in the science and technology curricula such as Biology, Chemistry, Physics, Electronics, Electricity, Mechanics and Control systems. Each subject can be learnt at three levels (5 points – high; 3 points – regular or 1 point – basic). Completing 7 points in Math, English, Literature and 7 points in the major subjects fulfills the precondition for admission to further education in Israel. Every point is equal to one hour per year during three years (10th–12th grades). Most of the schools in Israel route high achievers to high-level learning tracks and route low-achievers to low-level learning tracks. A learning track is a framework in which the pupil usually learns three subjects. In the Electricity track a pupil has to learn Electrical Systems, Electronics Switching and Control Systems. Each subject is studied for three – five hours per week, for three years.

The fostering of excellence among pupils majoring in the electricity track is a unique goal. These pupils were routed into this track and were labeled by the schools as low-achievers and were directed to lower level studies. This policy does not enable the pupils to reach the minimal admittance threshold that is needed to enter further education in college. In order to extract pupils and their teachers from the on-going cycle of failure, and to promote pupils cognitively and emotionally, alternative learning environments were constructed that focused on changing teaching methods.

The program goal was to augment self-image, increase motivation for learning, and promote all pupils towards success in matriculation examinations and towards further college-based education.

Participants

This program was implemented in five schools in the northern peripheral region of Israel. In each school, there were 15 pupils per class, 10th (fifteen years old) – 12th (eighteen years old) grades inclusive. This paper will focus on 54 pupils who started the program in its first year (1998, September), when they started the 10th grade, and who completed the 12th grade in 2001, July.

Mode of application

1. Defining significant goals for the pupils as well as for the teachers, in terms of setting schedules, attaining learning achievements, certificates of qualifications and professional diplomas.
2. Changing the learning environment: installing computers, P.L.Cs (Programmable Logical Controllers) and simulation software into new laboratories that were planned and built by the schools.
3. Applying alternative methods for teaching and learning.
4. Using computerized tools in various laboratory activities including project experiments, and substituting computer use for the routine frontal class teaching.
5. Developing warm and personal relationships between teachers and pupils, in order to encourage and support the pupils.
6. Enhancing basic subjects such as Mathematics and English.
7. Performing projects that take advantage of the pupils' special skills and abilities. Every pupil needed to be examined on a final project.
8. Changing assessment methods for PBL activities in a computerized environment.

A final project is a pedagogical instrument to increase pupils' motivation and interest. The project has interdisciplinary characteristics and summarizes the learning process over three years. It can be a tool for integrating ideas and themes from the electricity and electronics curriculum. A technological project is both practical and relates to pupils' everyday life. The demonstration of projects can act as a means for increasing the interest and expectations of younger pupils when they select what to study in high school.

The program activities focused on schools' basic needs, working side-by-side with the school management, the teachers, and the pupils. These activities have been implemented during the three years within the regular school timetable, and in auxiliary camps and workshops during vacations. Teachers' and pupils' activities during each year are presented in Table I.

One of the intervention's outcomes was a scale for assessing PBL. Table II presents the scale which was developed with the teachers during the intervention.

These criteria were used by the teachers as guide-lines during the tutor's

TABLE I
Teachers' and pupils' activities across three grades

Grade	Teachers	Pupils' products	Development of learning materials by staff
10th	In-service training 4 hours per week	Working on a mini project including simulation with EWB software.	A mini project: pupils learn how to build an alarm system, pupils perform simulations and experiments.
11th	Establishing weekly meetings between the teachers.	Portfolios documenting 15 experiments in Electricity. A mini project on PLCs. A project proposal and submitting it to the Ministry of Education. A medium level matriculation exam on electrical systems instead of the low-level matriculation exam, which schools used to let low-achievers take.	An expandable dossier that includes the whole matriculation exam with its solutions, in the three main subjects of electronics and electrical systems. Another expandable dossier that includes PBL applications for electrical and control systems. The dossier also includes 45 suggestions for different projects in electrical and control systems.
12th	Working on documentation and assessment of project-based learning.	A matriculation exam on the project in electrical and control systems. A basic-level matriculation exam on electronics. Medium level matriculation exams on Math and English.	Planning and creation of a youth camp at the end of the summer vacation between the 11th and the 12th grades. The camp's purpose was to advance PBL and to help the teachers guide the pupils in the initial stages.

process. The final pupils' portfolios have shown that the pupils documented their projects according to these criteria.

Enhancing PBL through a summer camp

One of the activities of the intervention program was a 5-day camp that took place in last week of the summer vacation between the 11th and 12th grades.

The camp's goals

1. Promoting project-based learning.
2. Helping the teachers to guide the pupils in the initial stages.

TABLE II
Criteria for assessing PBL

Criteria	Percentages (%)
Presenting the idea and writing a literature review.	10
Explaining the block diagram and the system structure and functioning.	5
Designing and constructing the PLC's ladder diagram and explaining the methods the ladder diagram controls system.	30
Performing a simulation, finding bugs and suggesting improvements.	10
Technical creation and construction, sub-systems.	15
Conclusions and writing the final portfolio.	15
Presenting the project.	15
Sum	100

3. Bringing the teachers together in order to increase their ability to guide pupils during project work. Assisting the teachers in technical and didactical problems during PBL.
4. Creating an interaction between pupils and teachers from different schools in the north of Israel, while they were working on several crucial tasks of planning, performing, and documenting their projects.

Preparations for the camp

Preparations for the camp were made over three months with the teachers' cooperation. The stages were:

1. Meetings with the teachers to explain the process of performing a final project. Most teachers were not aware of this procedure. Making a proposal and sending it for approval to the Ministry of Education. Documentation of the learning process during the pupils' work.
2. The teachers helped to propose ideas for the final project and a dossier was developed. The dossier included three parts: a description of the learning process up to the matriculation exam on the project; a collection of 45 ideas that were developed as proposals for the Ministry of Education; and an example of documentation for a project.
3. Suggestions were sent to the Ministry of Education for a first approval.
4. The teachers had a preparatory day in which the camp goals were set out, learning materials were introduced to the teachers, and the daily schedule was presented.
5. Every pupil received a folder containing all the materials that had been developed at the very beginning of the camp.

Some teachers and some principals resisted this process, claiming that 'electricity pupils' are too weak to perform a final project, which is a challenge even for high-achievers. They were afraid of behavior problems, and were worried that the pupils would not achieve the camp's main goal:

to complete the prototype, part of the control programs, and part of the documentation.

Ultimately, all the participating schools sent most of their pupils to the camp.

Daily schedule

08:00–13:00 – Project-based learning
13:00–14:00 – Lunch
14:00–19:00 – Touring the country/Swimming pool
19:00–20:00 – Dinner
20:00–22:30 – Leisure activities

In the middle of the second day, pupils from all the schools approached their teachers with the request to decrease the time spent touring and increase the PBL hours. So the afternoon schedule was adapted thus:

14:00–17:00 – Project-based learning
17:00–19:00 – Touring the country/Swimming pool

The final day's tour was cancelled in accordance with majority request.

METHOD

This article presents some of the findings of an active research which took place during three years. This research applied the qualitative methodology in which the researcher acts as the main tool for data collection. The interpretations or conclusions were examined and verified through repeated discussions with teachers, interviews with pupils and observations of class activities.

Subjects

The participants in this study were 54 pupils and 10 teachers who participated in a camp during the last week of the summer vacation between the 11th and 12th grades in five different high schools.

One school that did not want to participate in the program in its first year joined the program at the end of the second year with a teacher who was determined to foster his pupils' learning.

Data collection

1. Interviews with teachers and pupils.
2. Observations: Each year the researcher visited each school one – two times per week. A total of more than 150 visits per year. In each visit the researcher: observed class activities, discussed with teachers and management or interviewed pupils. Pupils' works, projects and tests, teachers' records and schools' documents were open to the researcher's

interpretation. The researcher actively participated in an in-service training the teachers took as part of the intervention program which includes 56 hours.
3. Questionnaire: The purpose was to assess pupils' attitudes towards the PBL activities.
4. Results of the final matriculation examinations.

FINDINGS

First, interviews and observations from the first two years of the intervention program are demonstrated. Then findings from the camp's assessment are presented.

In the first year 40 pupils from four schools were interviewed. In addition weekly observations in the classes, meetings with the teachers and with the school management were done. In order to get a wide perspective on the research group, some quotations, from the interviews with the pupils, are demonstrated.

David: '*All my friends think I am too stupid to learn other topics . . . ; that is the reason why I am learning in the electricity class*.'

Benny: '*People think that the electricity class is only for weak pupils who should be thrown out of school*.'

Henry: '*Everybody knows that we (the pupils from the electricity class) are disturbed. They are calling us "The grass class"* (A class in which most of the pupils stay outside the class on the grass) *because they know we don't learn*.'

These findings are strengthened by observations in the classes. The technology teachers were frustrated by teaching only the low-achievers in archaic laboratories.

In four schools this situation was repeated. The bored teachers in the archaic laboratories taught bored pupils. These observations in classes were part of a guidance process that had been taking place during the 10th and 11th grade.

In the second year after the laboratories were redecorated, installed with computers, simulation software and interesting assignments, the situation changed dramatically. The same teachers started to prepare interesting assignments for their pupils. The pupils were engaged with building an electrical alarm, utilizing EWB software (EWB – Electronic WorkBench is modern software for designing electrical circuits and performing a simulation of electronics components) and documenting their work with the assistance of a word processor. At the end of the year the pupils attended the matriculation examination in Electrical Systems.

All 54 pupils passed this examination with reasonable scores compared to the national average. These pupils started a new phase in their life at school at the end of their 11th grade. A five-day camp that took place in the summer vacation between the 11th and 12th grades was the crown jewel of this phase. The findings will concentrate on the assessment of the PBL during the 5-day summer camp.

First, observations made during the camp activities are presented. Second, examples of pupils' outcomes are shown. Third, data analysis from the assessment questionnaire filled in by all the pupils at the end of the camp is discussed. Finally, results of the matriculation exams demonstrate that the majority of the pupils fulfilled the precondition for admission to further education in Israel.

Observations

Three aspects of pupils' activities were pinpointed: variety of pupils' outcomes, progress rate, and pupils' behavior.

Variety of outcomes
All the pupils from the five participating schools completed a product that included four elements: an almost-finished model, ladder diagrams (A programming language used in Programmable Logical Controllers) at various stages, documentation of the construction process, and writing the introduction for the book project. Compared to the teachers' initial expectations, the pupils achieved high-level products.

Table III demonstrates that most of the pupils completed the camp with a high rate of progress.

Figure 1 shows evidence of the unique work every pupil succeeded in achieving during the camp and during the 12th grade.

These findings show that pupils achieved the camp goals. In the affective domain the PBL excited the pupils. Their motivation to learn, their discipline and their willingness to work on their projects longer hours indicate that they behaved like high achievers. In the cognitive domain, the pupils were brought to understand control concepts and applied them in the ladder diagrams. All ladder diagrams were more complex than the requirements of the matriculation examinations at a 3 point (regular) level. Some of the projects were fit to the requirements of the

TABLE III
Rate of progress

	Schools					
	A	b	c	d	e	Total
Total No. of Pupils	14	6	12	10	12	54
Completed model	93%	100%	100%	70%	67%	85%
A beginning of the ladder diagram	79%	67%	100%	50%	42%	69%
Partly documented control systems	93%	100%	100%	40%	67%	80%
Partly written introduction	79%	100%	100%	50%	67%	78%

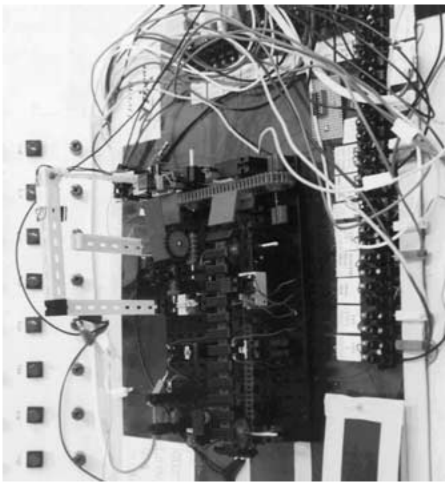

Figure 1a. Packing machine.

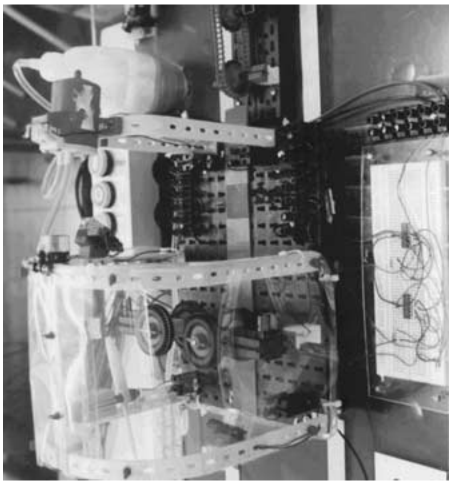

Figure 1b. Car washing machine.

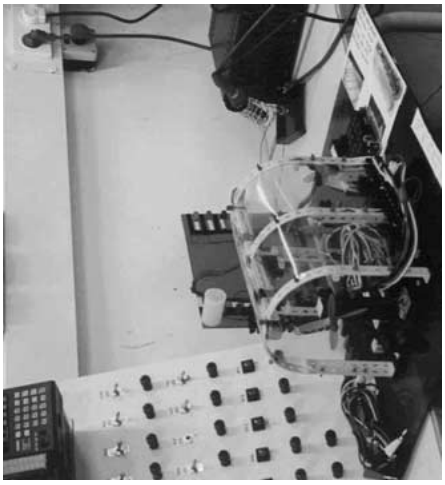

Figure 1c. Glasshouse.

Figure 1. Various projects.

matriculation examinations at a 5 point (high) level. The pupils wrote introductions that were longer than any material they had ever written in Science-Technology subjects. In the matriculation examinations that took places at all five schools assessment of the 54 project lasted with high scores. In one of the school, the examiner said ‘I did not think these pupils would succeed in making such creative projects’.

Questionnaire findings

The questionnaire consisted of two parts: open references by the pupils to the camp and closed questions regarding the camp activities.

Summary of open references

Most of the pupils see the camp as an activity worth participating in, although it took place in the last week of their summer vacation.

Most of the pupils think that the cooperation between their teachers helped them to attain the camp’s goals.

The interaction between pupils from different schools was mentioned as a unique event. This can be regarded as a recommendation for the education system to increase learning interactions among pupils from different schools.

Most of the pupils emphasized that the camp made them believe in themselves. They started to talk about making more effort in the 12th grade in order to take matriculation exams in Math and English.

The pupils notice that their teachers became partners in the learning process. Suddenly, not all the answers were written in the teachers’ notebook or in their text books. They needed to search the internet for materials and consult with other pupils, teachers and tutors.

Summary of the closed questions

Table IV relates to the pupils’ attitude towards PBL, planning and constructing ladder diagrams. The scale was 5 (definitely agree) to 1 (don’t agree at all).

These findings show that the camp was successful from the pupils’ viewpoint. Table IV illustrates that PBL was very interesting for these pupils. Figure 2 and Figure 3 strengthen the impression that teachers can promote low-achievers towards better learning, and strengthen their motivation to succeed.

Recommending that other pupils participate in educational activity indicates that these pupils felt that the camp’s contribution to them was significance.

Willingness to participate in another camp during another vacation strengthens the evidence that low-achievers want to invest their free time in interesting learning.

Figure 4 shows that 98% of the pupils enjoyed PBL and it was interesting for them.

TABLE IV
Pupils' attitudes towards the camp

Statement	Mean	Std
Learning through project creation is very interesting to me.	4.71	0.66
My participation in the camp will contribute to my completion of the final project successfully.	4.72	0.67
The organization of the camp was excellent.	4.42	0.79
The subjects were taught interestingly and attractively.	4.42	0.80
The instructors were very helpful in the construction process of the project.	4.59	0.87
I intend to recommend 11th grade pupils to participate in this camp next year.	4.47	1.03
If a similar camp is arranged for the winter vacation, there is no way I will miss it.	4.46	1.06
The learning materials I got in the camp were comprehensive and contributed to the creation of my project.	4.41	1.05
There were subjects which enriched me beyond the requisite study topics.	4.21	1.12
I feel that (now) I have a good understanding of ladder diagrams.	3.91	1.01

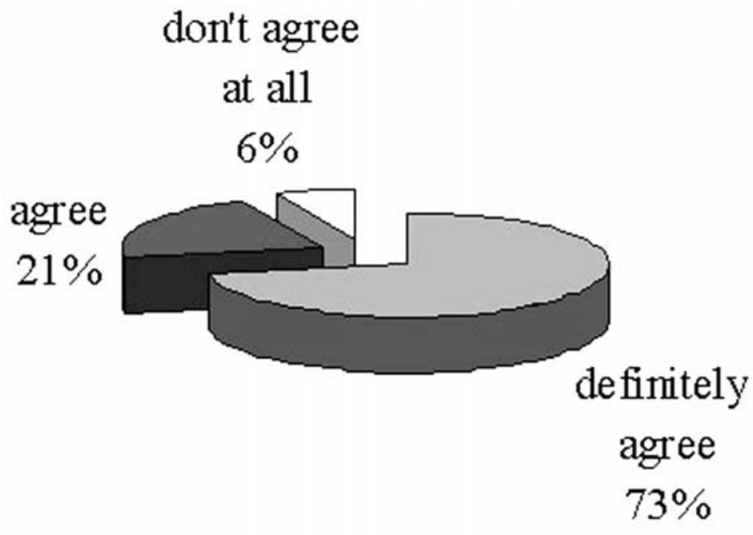

Figure 2. I intend to recommend pupils from the 11th class to participate in the camp.

Meetings with the teachers

Meetings with the teachers took place informally during the PBL sessions. The teachers consulted with their mentors in order to improve the guidance they could offer pupils in need. Twice a day, a general meeting was held, after the lunch meal and after dinner. During the meetings, the teachers reported when they lacked some electrical parts, and an effort was made

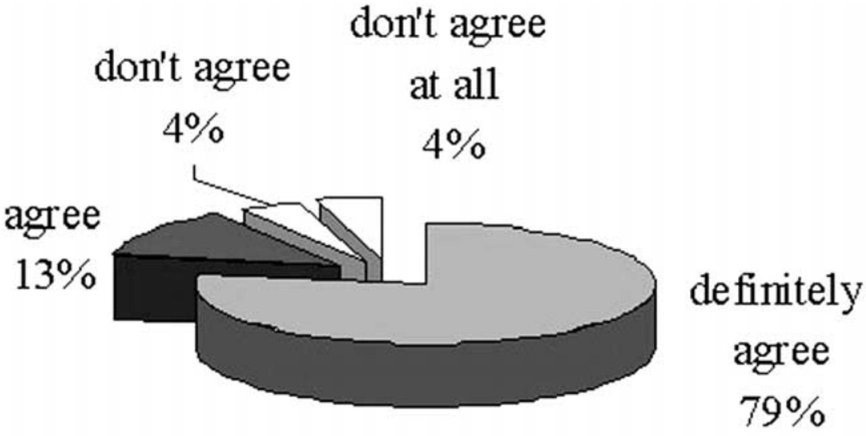

Figure 3. If a similar camp is arranged for the winter vacation, there is no way I will miss it.

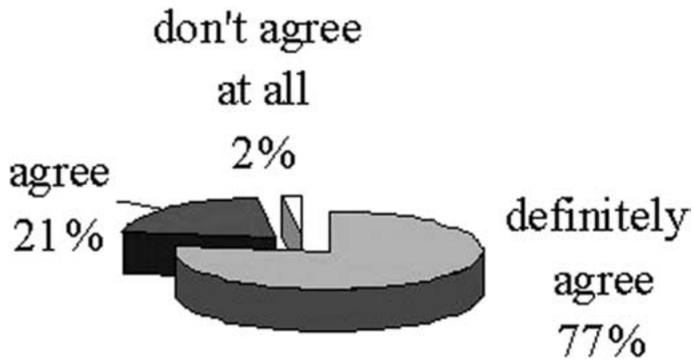

Figure 4. Project-based learning is very interesting to me.

to supply these parts during the camp. Usually, the teachers were united in their opinion that the camp was well organized and that the guidance was satisfactory.

One of the teachers thought that the guidance was too helpful for the pupils and prevented them from solving their problem more autonomously. All the other teachers disagreed and justified their opinion by bringing examples of problems that the pupils dealt with alone or with minor guidance that gave only a general direction to the solution.

The teachers unanimously expressed that they had learnt from the guidance process and that they had gained experience they could use in the future in order to guide themselves in the school. The teachers mentioned, also, the positive interaction with teachers from other schools.

Findings from the final matriculation examinations

As mentioned above, almost 80 pupils from five different schools participated from the beginning in the three-year intervention program. Pupils who reached the 12th grade took final matriculation examinations in their major subjects such as Electrical Systems, Control Systems and Electronics Switching. As mentioned earlier, these subjects along with Math, English and Literature fulfill the precondition for admission to further education in Israel. Table V shows a comparison between two years: 2001 and 2000. Pupils who graduated school in 2001 had being participated in the intervention program since 1998.

The findings from Table V show that 69% of the pupils fulfilled the precondition for admission to further education in Israel. In previous years most of the pupils could not do so as the results in the column 2000 show.

CONCLUSIONS

The findings indicate that scientific-technological PBL elevated pupils' motivation and self-image in all levels. These findings strengthen other works' conclusions about meaningful learning that PBL fosters (Barak & Doppelt 1999; Barak et al. 1995; Doppelt & Barak 2002). Summarizing three years of activities show an increase in the number of pupils who were low-achievers at the end of the junior high school and completed high school with the fulfillment of the precondition for admission to further education in Israel.

PBL turned out to be 'the crown jewel' of the studies in the electricity track. It allows integration of subjects and is a challenge for the pupils who solve interdisciplinary problems. Working on a technological project forced the pupils to use several competencies. They planned, built, programmed, and documented their progress. Using the computer as a tool in designing, surfing the Internet for information, carrying out simulations, control of engineering systems and a tool for project documentation is one of the main factors in effecting a change in the learning processes in schools. The participants in this study created authentic projects which

TABLE V
Pupils who can continue towards further education

Schools	10th grade	Final Examinations	Percentage (2001)	Percentage (2000)
a	18	14	78%	0%
b	10	6	60%	0%
c	22	12	55%	21%
d	14	10	71%	41%
e	14	12	86%	79%
Total	78	54	69%	28%

forced them to use creative thinking during their design process. The contribution of infusing creative thinking in to PBL was described elsewhere (Barak & Doppelt 2000; Doppelt 2003).

This study focused on a small sample (54 pupils and 10 teachers). But, the follow up of pupils' activities and teachers' professional development during three years strengthen past research that demonstrated the possibilities that PBL in a computerized environment enables the low-achievers (Doppelt & Armon 1999).

The assessment process in PBL in a computerized environment emerges as a task whose success may act as momentum in promoting learning/teaching processes in schools. In this study, pupils documented their projects according to the criteria the teachers developed during the intervention program. Consensus between the teachers led them to implement those criteria during their guidance process.

FINAL REMARKS

During the following school year, the pupils finished their projects. The project included a model, a ladder diagram, simulations, and documentation of the PBL every pupil experienced. Every pupil presented the project in an exhibition in which parents and other teachers were invited to attend. All the 54 pupils passed the matriculation examination in which an external supervisor comes to every school to examine pupils' competencies and knowledge. Barlex (1994) summarizes his article: 'It is difficult to capture the breath of spring that successful technology project work brings to a wintry curriculum. Perhaps it's the risk of failure and the uncertainty with no right answers, only possible solutions'.

The teachers changed their role in class to creative mentors who foster pupils' competencies, instead of guarding and nurturing the pupils who continue to come from the low-achieving population at the schools. The teachers from the 'Electrical and Control' department started to believe in their ability to foster their pupils' competencies and knowledge towards achieving the college admission requirements. Pupils act according to the school's expectations, and the teachers have a crucial role in changing the school's attitude to extract the pupils from the cycle of failures.

These findings encouraged us to focus on the characteristics of the learning process in a rich learning environment. Teachers have a new role to play. They have to inspire an atmosphere of comfort, love, self-confidence, learning from mistakes, and teamwork. Every teacher has to encourage his pupils to think, to use their knowledge, and to apply their own ideas to authentic projects. Any teacher, who creates such a climate, discovers that pupils, even under-achievers, get involved in the learning process and choose their own goals for learning. As a result of these changes in the classroom framework, the pupils become better learners.

It is the role of the school and the teacher to adjust the learning environment to pupils needs. We better stop looking at pupils' difficulties, instead, let us develop their talents. As the words of the song: 'always look at the bright side of life'. We should not look at the glass as being half-empty but rather as being half-full.

PBL has made a tremendous change in the pupils' life in school. This change started developing their self-responsibility for their learning processes. Raising their self-esteem and self-confidence was the next step. Creating reachable challenges for them made them feel their first successes at school after long time. After first successes had come, the pupils started to succeed in other areas. They became a united group with one goal: to succeed in performing their authentic projects and to succeed in the matriculation examination. Isn't it wonderful?

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