ARISE
Action Research and Innovation in Science Education, 1(2), 9-17

www.arisejournal.com
ISSN: 2626-9902

RESEARCH ARTICLE

How Project-Based Learning promotes 7th grade students' motivation and attitudes towards studying biology

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This study examines how Project-Based Learning (PBL) influences the attitudes and motivation of middle-school biology students in the Arab sector of Israel to learn biology. The research population consisted of 7th grade students (n=178) from six biology classes in northern Israel. The two-month study used a mixed methods research design: quantitative (questionnaires) as well as qualitative (a semi-structured interview with students). The two research hypotheses were as follows: (1) PBL increases student motivation; and (2) PBL improves student attitudes. The study's findings indicate that an intervention that combines the teaching of biology with PBL results in both increased motivation among students and more positive attitudes towards studying biology. Students reported greater pleasure, curiosity, interest, and cooperation when PBL was used. The findings suggest that introducing PBL can bring about improvements in both student motivation and their attitudes. The conclusions derived from these findings can help in formulating recommendations for applying PBL in biology and perhaps in other subjects as well, especially in the Arab sector of Israel.

Keywords: Biology, project-based learning, PBL, student attitudes, student motivation

◆Received 12 August 2018 ◆Revised 23 December 2018 ◆Accepted 26 December 2018

Introduction

Students' motivation and their attitudes are important both for ensuring optimal learning and for their academic success. Many students have trouble learning science, a fact that affects their motivation and their attitudes toward studying it (Deci Vallerand, Pelletier & Ryan, 1991; Prokop, Prokop & Tunnicliffe, 2007). In Israel, the most common methods for teaching science, especially in the Arab sector, have been teacher-centered. Here, "the student functions as a passive receiver of information … the responsibility for the learning process focuses on the teacher, who plays a key role in students' acquisition of knowledge" (Markic et al., 2016). In contrast, student-centered methods directly involve students in the learning process. Here, students take responsibility for their learning, which takes place actively. Students acquire knowledge by means of their personal experience and structure the materials that they learn; here the teacher acts as a guide who helps students achieve their educational goals (Wolk, 2010). Several different student-centered teaching methods are now used in schools all over the world. This study focuses on the Project-Based Learning (PBL) method.

PBL is a process organized around a project. Learning takes place in groups that are required to perform complex tasks whose output is usually a concrete product. Students present the product to their peers and reflect on the learning process, while the teacher guides, constructs tasks, poses challenging questions, and encourages the development of social skills, information collection, and critical thinking (David, 2008; Ministry of Education, 2014).

Studies that examined the PBL method found that it is more efficient than traditional learning, because it offers a broad variety of learning possibilities, so that each student can learn in accordance with his or her abilities (Bell, 2010). In addition, most studies validate the students' high motivation and their positive attitudes towards PBL (Filippatou & Kaldi, 2010; Kaldi, Filippatou & Govaris, 2011). It was found that students seek study materials at a higher level than the level at which they are studying in order to learn more, and that they spend more time in preparing academic projects than in learning according to the traditional method (Bell, 2010). When learning using the PBL method, students have a more positive attitude towards collective work and experiential learning, when compared to traditional learning (Baş & Beyhan, 2010). This result is reinforced by studies in science teaching, which found that it is important for teachers to change their beliefs concerning their preferred teaching method, and the studies stress the importance of using teaching methods that place the student at the center rather than the teacher (Kim, 2005; Lam, Cheng & Ma, 2009).

Theoretical framework

Teaching methods

There are many teaching methods, e.g., the "traditional" method with the teacher at the center, and the "constructivist" method, in which the student is at the center. In the Arab sector in Israel the traditional method dominates (Markic et al., 2016). In this method the teacher is the center of attention; students are passive receivers of information. The teacher makes all the decisions

http://10.12973/arise/103043
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concerning the curriculum and the teaching and assessment methods (Ahmed, 2013). Lecture-style instruction or teacher-centered instruction is common and knowledge is imparted uniformly by the teacher, with no regard for the differences among the students, who listen passively, write down, and summarize what the teacher says (Brooks & Brooks, 1993). According to Duckworth (2009), when the teacher is put at the center, students find it difficult to develop academically.

The other paradigm or research program is constructivism such as PBL, which places the student at the center. Here students learn actively; they decide what subjects to learn, when to learn and by which method. They are responsible for their learning and are directly involved in the learning process. In this method, the teacher uses an active and cooperative teaching style (Wohlfarth et al., 2008); his role is to guide and help students achieve their learning goals (Wolk, 2010). The principle of constructivist learning points to an active learning process, whereby students reconstruct information. Learning in this way involves creating meaning and constructing a personal interpretation of the world, based on personal experience (Dolmans, De Grave, Wolfhagen & Van Der Vleuten, 2005). The constructivist approach has inspired the development of a variety of teaching methods used in various schools.

Project-based learning (PBL)

PBL is one of the best methods for developing broad learning capabilities among students (Barak, 2012; Terasawa, 2016). It promotes student interest in science and improves their understanding of science content (Langbeheim, 2015). In this method, the inquiry process is organized around a project, an output that motivates student activity. Learning involves accomplishing complex tasks whose output is usually an "artifact", a concrete product such as a model, a picture, or a presentation. Students present their product before an audience (presentation), explain it, and reflect on the learning process. In this method, the teacher constructs tasks, asks challenging questions, as well as directs and encourages the development of information and social skills. Finally, the teacher evaluates the learning and the knowledge that the students obtained from the experience (Ministry of Education, 2014). PBL can be divided into the following stages (Ministry of Education, 2014):

1. Students are presented with an intriguing question, an open question to which there is no single answer and which is broad enough to enable students to pose other questions. For example: Does nature speak? After the question is presented, the students are asked to compose an essay, using associations related to the question, and by posing questions that interest them. The essay defines the expected direction of the student's research.
2. Students choose the desired product, which constitutes the engine for the learning process. The product should be meaningful in the real world, for example, creating an educational game for children who are hospitalized for a long time.
3. The teacher focuses on elements that he will want to evaluate during the learning process, such as textual analysis and computer skills.
4. The teacher uses a variety of ways to explain the basic concepts needed for the project and allows the students to choose their sources of information and to deal with them critically. It is important to use a variety of different sources. In addition, students may collect information from experts in the field and from places of learning within the community. Experts in the field of the project may be invited to visit the classroom.
5. Intermediate results are presented to the other groups, so that each group can get feedback from its peers. This stage may be repeated a number of time, in accordance with students' need for feedback, in order to improve the intermediate product and arrive at a final improved version.
6. Each group presents its product, e.g., in the form of a computer presentation, presented to the class and other viewers, such as parents and the experts who accompanied the process. It is important for the audience to participate by asking questions.
7. The student reflects on the learning process, observes himself as a student and a human being, and defines his areas of growth in the learning process and the challenges with which he had to cope.

PBL creates opportunities for students to conduct inquiries into significant topics that require a variety of skills (David, 2008), identified by Ravitz, Hixson, English and Mergendoller (2012) as the following:

1. Scientific thinking: The ability to identify problems, assess various information sources, and come to appropriate conclusions.
2. Cooperative working skills: The ability to work together effectively and respectfully with a group of people towards a common goal.
3. Interpersonal communication: The ability to organize ideas, knowledge, and findings and share them with members of the group orally or in writing.
4. Creativity: The ability to collect information and arrive at solutions, then to present them in an original and creative manner.
5. Self-regulation: The ability to take responsibility and to study independently; the ability to observe and criticize one's own output and to respond to feedback.
6. Skills related to the research topic: Any skill required for dealing with the specific topic, such as political knowhow, language skills, and photography.
7. Use of technology: The ability to use technological sources of knowledge appropriately.

PBL creates a link between practical and intellectual activity (Solomon, 2003), promotes significant learning, associates new learning with previous experience and knowledge, and enables students to experience a variety of communication and knowledge-presentation situations (Westwood, 2006). In addition, it constitutes a more efficient method than traditional learning does, because it helps students adapt to different learning styles (Kaldi et al., 2011), and provides a broad variety of learning possibilities, so that each student can participate and can choose an appropriate learning level. The element of choice is an important component of student success (Bell, 2010). The PBL method enables students to acquire knowledge and abilities by inquiry and involvement in complex problems and challenges (Coyne, Hollas & Potter, 2016). According to

Moylan (2008) and Stefanou, Stolk, Prince, Chen and Lord (2013), PBL enables students to learn from the best teacher, namely, the student himself. In other words, PBL induces students to develop self-learning skills, which are very important in the new age of information technology. According to Özdemir, Yildiz and Yildiz (2015), using a project-based learning approach induces a creative classroom atmosphere; students generally perceive project work as enjoyable and entertaining.

Students' motivation and PBL

In PBL, students are usually driven by intrinsic motivation. Intrinsic motivation is a willingness to invest time and effort in a certain activity even if it involves difficulties (Deci & Ryan, 1985). Intrinsic motivation is accompanied by a sense of free choice and does not depend on external reinforcement. It has been found that in PBL the students search for study materials that are at a more advanced level than their own in order to learn more, and that they are willing to invest more time in preparing their project than is the case in traditional learning (Bell, 2010).

Teachers know that practical activities, especially projects, create motivation in students, and that this motivation increases when they feel that they have control over their work (Bahar, 2009). In a study (Baş & Beyhan, 2010) that compared the motivation of students who learned English using the PBL method with that of students who learned using the traditional method, it was found that the motivation of the students who used the PBL method was higher than in the control group that used the traditional method. However, Lamet al. (2009) found that student motivation was not affected by the teaching method, but rather by how motivated teachers were in using a given method: When teachers were highly motivated to use PBL, they supported the learning process (the project), and this in turn, had a positive effect on student motivation.

Students' attitudes and PBL

Various studies (Baş & Beyhan, 2010; Kaldi et al., 2011) have shown that when the PBL method is implemented, students develop a positive attitude and evaluate their collective work and experiential learning positively, in comparison with traditional learning. Furthermore, it has been found that children with learning disabilities prefer PBL to the traditional method, and that their motivation and academic achievements are positively affected when using the former (Filppatou & Kaldi, 2010). However, a study in Taiwan (Tseng, Chang, Lou & Chen, 2013) provided evidence that student attitudes towards project-based learning were culture-dependent and were also affected by the teacher's knowledge, and that the use of PBL did not change student attitudes towards the subject matter. In a study by Genc (2015) that examined the effect of PBL on student attitudes towards the environment, it was found that this method had a positive effect on attitudes and also improved student creativity and encouraged inquiry-based learning. Genc contends that students believe that this method helps them define environmental problems more clearly and makes them participate in a problem-solving process.

Motivation and attitudes are important components of learning and academic success. Many students consider the sciences to be boring, difficult, and irrelevant subjects (Prokop, Prokop & Tunnicliffe, 2007), and this consequently affects their attitudes and their motivation towards studying science. Nolen (2003) argued that if instructors emphasize memorization in learning science, it may lead students to view it as a boring and impractical subject.

Since the present study focuses on the effect of PBL on student attitudes and their motivation towards studying biology in the Arab sector of Israel, the following section will provide a brief overview of the school system in that sector.

Research questions

According to the professional literature, we can assume that the use of the PBL method will improve students' motivation and attitudes towards studying biology. The following research questions were derived from a survey of the literature:

1. What effect does the PBL method have on 7th grade students' motivation to study biology?
2. What effect does the PBL method have on 7th grade students' attitudes towards studying biology?

Based on these two questions, the following research hypotheses were formulated:

1. PBL will improve students' motivation to study biology.
2. PBL will result in students having more positive attitudes toward biology.

Research design, sample and methods

The study was conducted using a mixed-methods design focusing the innovation of implementing PBL into science teaching. The quantitative part took the form of questionnaires and the qualitative part consisted of a semi-structured interview with students, to glean information from the students and to cross-check it with the findings of the quantitative part.

Research population

In this quasi-experimental study, the research population consisted of 178 7th grade students from 6 classes in a school in the Arab sector in northern Israel. Israel is a multicultural state; the Jewish and the Arab communities are the biggest sectors. The Jewish and Arab sectors have the same school system. School is compulsory until the age of 16. In upper secondary education, different types of schools with different academic and vocational orientations are available. However, Israel has a centralized educational system. The syllabi and curricula are regulated by the Ministry of Education. Only the language used for teaching as well as cultural issues in the curriculum is specific for the respective sector.

For many decades the Arab schools in Israel were characterized as being teacher-centered. The traditional teaching method was the most commonly one used. In this method the student functions as a passive receiver of information; here the responsibility for the learning process focuses on the teacher, who plays a key role in students' acquisition of knowledge (Markic et al., 2016).

Two different teachers taught the six classes: one teacher taught two of the classes and the other taught the other four classes. Both teachers underwent training in the use of the PBL method and were continually accompanied throughout the research.

Research tools

The research tools consisted of two questionnaires for the quantitative part. In addition, the qualitative part consisted of semi-structured interviews.

Motivation questionnaire: The questionnaire, developed by Khalil (2001), examines students' motivation to learn. It consists of 14 statements on a five-point Likert scale (1 = never; 5 = always). The reported Cronbach's alpha was 0.80, indicating a relatively high degree of reliability.

Attitudes questionnaire: The questionnaire, developed by Shah and Mahmood (2011), examines student attitudes towards biology. It consists of 24 statements on a five-point Likert scale (1 = never; 5 = always). The reported Cronbach's alpha was 0.86, indicating a relatively high degree of reliability.

In order to ensure maximal reliability, the questionnaires were translated into Arabic by experts. The motivation questionnaire (originally formulated in Hebrew by an expert in Hebrew) and the attitudes questionnaire (originally formulated in English by an expert in English), were given to an expert in Arabic who was asked to ensure that the statements were formulated correctly and clearly. His comments focused on problems of clarity and grammar. After they were incorporated into the questionnaires, they were given to a Hebrew teacher and an English teacher, respectively, who were not familiar with the original questionnaires in Hebrew and English, to be translated back into Hebrew and English, respectively. The versions were then compared and found to be completely consistent with each other.

Semi-structured interview: The qualitative part of the study consisted of a semi-structured interview with a representative sample of students, chosen from all the classes and representing all levels of accomplishment, and with both sexes represented equally.

Research procedure

The study was conducted in the following stages:

1. Pre-questionnaires: In order to determine whether there was a difference in attitudes and motivation among students before the intervention, every student completed the motivation and attitudes questionnaires. The two questionnaires were handed out in different lessons, to prevent overload and careless answers. A complete lesson (45 minutes) was dedicated to completing each of the questionnaires. The students were informed that the questionnaire was anonymous and would not affect their grade in biology.

2. Both teachers were given the same instructions regarding the principles of PBL, by means of presentations and acquainting them with the teaching sequence used in this method. In addition, the teachers received full support throughout the study.

3. *The intervention:* Students in the biology class used the PBL method to learn about "the cell" for 16 lessons:

- Students were presented with the topics needed for preparing a project on the cell.

- The students were divided into groups of four. Each group chose a project according to a vote taken by the group after a discussion among its members. Each group worked on the project for about two months. The teacher explained the special intervention method and its advantages, showed YouTube films about schools that participated in similar projects and their experiences with them, posed questions, guided the students in each group and, of course, explained the difficulties that they would encounter.

- The topics chosen for the projects were varied. Here are some of the projects prepared by the students.

  • A model of a plant cell and an animal cell, with the names of the organelles and their parts, and highlighting the differences between them.

  • A presentation of unicellular organisms, consisting of information, photographs, and films.

  • A poster about microscopes, showing the various types of microscopes (optical, electronic, scanning, and binocular) and how each is used.

  • A memory game: 20 cards, with pairs of cards, one with a picture and the other with information about the object in the picture.

  • A trivia game, with questions about the cell. The purpose of the game is to enhance the players' knowledge about the cell and to encourage students to compete in an enjoyable and challenging manner.

  • An exhibition of pictures of cells drawn by the students, focusing on the principle of "adapting structure to function".

  • An invited lecture by an expert from the Techion (a university) on current research on the cell. The role of the student was to coordinate with the expert on the subject of the lecture and present him with a summary of what was done.

- After the projects were completed, all the students met and conferred, after the teacher received permission from the principal to show all the presentations, one after the other, during three consecutive lessons.

- Each group presented what it had prepared to the class for 15 to 20 minutes, including reflection on the procedure used for preparing the project.

Note that the preparation of the projects required a great deal of investment for both the students, and the teachers who guided the students and were under considerable pressure, especially to teach all the required materials.

4. *Post-questionnaires:* After the learning was completed, each student was asked to complete again the motivation and attitudes questionnaires, identical to the pre-questionnaires.

5. *Interviews:* After the post-questionnaires were conducted, semi-structured interviews were conducted with 15 students. Each interview lasted about 30 minutes. In a talk before the interviews, the purpose of the interview was explained to the students, in order to create a pleasant atmosphere and to motivate them to cooperate. The interviewees were told that their replies would be used solely for research purposes and that it would be impossible to identify them.

Data analysis

A t-test was carried out in order to examine the first and second research hypotheses. The test determined the mean differences in the students' levels of motivation and in their attitudes towards studying biology.

The qualitative findings from the semi-structured interviews elicited student reactions on topics relevant for implementing PBL in their classes, including their assessment of the method. The qualitative analysis combined a bottom-up approach: The analysis of the data collected in the interviews revealed similarities that made it possible to present common patterns. Text passages from the interviews were classified according to the topic (categorization). Each passage was classified under an appropriate topic. This process gave meaning to the data by revealing the relevant features in the material. The findings were described and summarized in quotes from the students.

Findings and discussion

Analysis of the quantitative data

The quantitative data were analyzed with respect to the two research hypotheses. Table 1 presents the data for the motivation.

Table 1. *Differences in students' motivation before and after combining the PBL method.*

Stage	N	M ± Sd	*t*(*df*)
Pre	178	3.70 ± 0.72	t(176) = 0.308
Post	178	3.92 ± 0.71	

Table 1 shows that at a significance level of 0.05, the difference in the students' motivation mean between the pre (M = 3.70) and the post (M = 3.92) was statistically significant (t(176)= 0.308, p = 0.032 <0.05).

In order to determine the attitudes towards learning biology, a t-test was conducted. Table 2 presents the data:

Table 2. *Differences in students' attitudes before and after using the PBL method.*

Stage	N	M ± Sd	*t*(*df*)
Pre	178	3.37 ± 0.57	t(176) = 0.491
Post	178	4.54 ± 0.55	

Table 2 shows that at a significance level of 0.05, the difference in the students' mean attitudes towards studying biology between the pre (M = 3.37) and the post (M = 4.54) was statistically significant (t(176)= 0.491, p = 0.042<0.05).

Analysis of the qualitative data

The interviews revealed similarities that reflect common patterns among the interviewees, which can be divided into the following three categories:

- *Student satisfaction and enjoyment:* The interviews indicated that some of the students were interested in the PBL method and felt that it was more enjoyable, challenging, and interesting, because it promotes freedom of expression and inquiry-based learning. In addition, this method extended their introduction to a variety of information sources (Internet, YouTube, and others). Moreover, it provides emotional support for the students: inclusion, consideration, and encouragement. Some students also noted that the project's presentation was very significant for them.

- *Student difficulties and fears:* Analysis of the interviews provided insight into the difficulties and fears that students coped in the course of learning. Some students expressed a lack of interest in the subject that was chosen for the projects (the cell). Others found it difficult to work within a group; some of them complained that *"we were forced to do the task without the other members of the group participating"*. There were students who maintained that *"we were unable to express ourselves enough while preparing the project, because one member of the group did most of the work"*. Others complained that they did not receive enough guidance from the teacher and therefore, they did not know exactly what was expected of them. There were students who noted that *"the teacher did not give us enough time"* or that *"the teacher's comments on our project were not focused and were insufficient, which caused the project to look the way it did, that is, not good"*. In addition, some of the students said that *"we participated in the project because we feared that the teacher would give us a lower grade in biology"*. One student noted that for him the reflection activity was *"something scary"*.

- *Student achievements:* Some of the students stated that *"PBL helped me understand the content of the material in a more profound way"*, or that *"the learning method* caused me to made a

greater effort to understand by myself and to explain it better to the other members of the group". Others noted that they *"expect that our grades in the next biology test will improve"*.

Discussion

As previously noted, the purpose of the study was to examine how PBL affects 7th grade students' motivation and attitudes towards biology. The analysis of the questionnaire data, as presented in table 1, shows a significant difference between "pre" and "post", thus confirming the research hypothesis that PBL affects students' intrinsic motivation: they were more creative, curious, and responsible, and experienced excitement and a challenge. This result is consistent with previous studies that showed that PBL results in greater motivation than the traditional teaching method (Baş & Beyhan, 2010). In addition, Bell (2010) argues that in PBL the students are willing to invest more time and effort than in traditional learning. Our findings are also in line with those of Barak (2012), who noted that a learning environment in which there is rational use of PBL makes it possible for teachers to teach with more variety, it can change the interaction patterns between teachers and their students, and it enables teachers to pay more attention to differences among students. He claimed that such an environment makes it possible to carry out challenging tasks that are related to students' daily lives and to present opportunities for teamwork. As a result, Barak argues that PBL can be expected to improve student motivation, promote learning skills, and create a situation in which many students will be able to bring their full abilities into play and to improve their academic achievements.

On the other hand, some studies have shown no significant difference, or only a small difference, in student motivation following the use of PBL. Kaldi and colleagues (2011) found that student motivation changed little after PBL. Students did not express a special fondness for the method, although it did provide them with teamwork skills and subject knowledge. Another study (Skaalvik & Skaalvik, 2004) reported that students with low motivation and who had studied mathematics using the PBL method did not show an improvement in motivation afterwards. The students noted that they still did not like math, just as before. The researchers explained that the findings were due to the fact that people tend to avoid things at which they are not very good. Furthermore, Lam et al. (2009) found that student motivation was not affected by the teaching method; rather, it depended on the teacher's own motivation: A teacher who was highly motivated to use PBL supported his students during their learning process, and this was what improved their motivation. The results are in accordance with a study by Bingolbali and colleagues (2007), who concluded that the PBL activity was the major cause of raising students' interest in learning and their motivation towards studying engineering.

The quantitative data received support from the analysis of the qualitative data. Some of the students enjoyed their learning experience, which they perceived as a refreshing change that helped them gain a better and more profound understanding of the study material: *"I understood the subject matter more deeply, because I searched for materials in the library and on the internet. In addition, I had to explain it to the group, so I had to learn it well"*.

Students also maintained that they gained new learning skills associated with the search for information and the use of teamwork: *"I learned to search using different sources of information. I learned how to search in a library. Now I know how the books are arranged in the library, by subject. Next time it will be easier and faster to find what I am looking for"*. Also: *"What helped me understand was preparing the final project, because we had to work together and therefore we studied the subject together. When someone did not understand something, we helped him"*. Some of the students said that they like biology, which they find very interesting and which they would be happy to study in the coming years as well: *"I think that biology is an interesting subject. The project made me enjoy learning very much"*, and: *"My brother studies biology at the university. I think that the project we did is similar to how he learns there. Since last year, I wanted to start learning biology, which I enjoy very much"*.

In addition, the results reflected in table 2 show a significant difference in students' attitudes towards biology, thus also confirming the research hypothesis. This finding is consistent with the conclusions reached in previous studies indicating that students who learn by the PBL method tend to develop positive attitudes and can positively assess their collective learning experience in comparison with traditional learning (Baş & Beyhan, 2010; Kaldi et al., 2011). Furthermore, it was reported that students with various learning disabilities prefer PBL, which helps improve their academic achievements (Filippatou & Kaldi, 2010).

On the other hand, a study conducted in Taiwan (Tseng et al., 2013) found that students' attitudes towards the subject matter did not change in spite of PBL. The researchers hypothesized that students' attitudes were culture dependent and were affected by the teacher's knowledge. Kanter (2010) also found that students' attitudes after the use of PBL did not change, nor did their desire to study science in the future. Indeed, apparently the success of PBL depends on the teacher's familiarity with the method and on the frequency with which it is used. Karacalli and Korur (2014) claimed that whether or not students' attitudes towards PBL and traditional teaching methods change depends on the amount of time that students have experienced PBL, mainly because attitudes cannot change very quickly. In order for PBL to bring about a change in an individual's attitudes, enough time must be given for students to experience the method. They explained that PBL was used only for their study, and only for a short time, and that this was the first time that the students encountered this kind of learning. The results of this study are in line with those of Hugerat (2016), who revealed that students who learned science by project-based teaching strategies perceived their classroom learning climate as significantly more satisfying and enjoyable, with greater teacher support, and with significantly more positive teacher-student relationships.

On the other hand, students who had experienced collective work, as expected when using PBL and who had divided the work on their project equally, had a pleasant experience. They enjoyed what they did, learned to appreciate teamwork, and hoped that they would be able to use PBL in

other lessons as well. Some typical commends are as follows: *"I really enjoyed the lessons, because they were different from the other lessons that we are used to"*, and: *"I would be happy to learn other topics and other subjects using the same method, because I liked the freedom we had to plan the learning and the teamwork"*.

To summarize this discussion, Thomas (2000) conducted a comprehensive survey of studies on PBL. He concluded that the challenges in implementing this learning method can be divided into three categories: 1) Challenges that students face, for example, time management, lack of motivation, lack of knowledge and experience in inquiry processes, data usage and coming to conclusions; 2) Challenges that teachers face, for example, time management (finishing the projects and covering all the material in the curriculum), class management (the different projects in the class), giving support to students (many students, different topics), and assessing the students' work; 3) Challenges stemming from the school, for example, rigid schedules, lack of support from the school administration, and lack of appropriate technological aids. We feel that in the current study we reached similar conclusions.

Summary and outlook

The current study focused on the attitudes and motivation of students in the Arab sector in Israel. The prevalent teaching method in this sector is the traditional frontal method. The study pointed to significant differences in students' attitudes and motivation toward studying biology. An analysis of the qualitative findings showed that some students who learned using the PBL method enjoyed the experience and reported that they found it more interesting and challenging, because it encourages freedom of action and expression. In addition, they confirmed that PBL helped them understand the subject matter better and more profoundly because they had to search for materials themselves and were required to explain it to the other students. In the interviews some students noted that not everyone participated equally, so that in some cases one or two students in the group did most of the work on the project.

The importance of the present study and its contribution lies in the fact that it may indicate that an innovative, modern teaching method can by implemented in a conservative traditional sector in which the teacher is perceived as an authority figure and in which teaching takes place frontally, with the students listening docilely. The study's importance lies in its contribution to the teacher's development in the context of using teaching methods in which students are actively involved, in the belief that a constructivist learning environment, as in PBL, promotes motivation and can bring about more positive attitudes towards learning the sciences.

The study's findings can also contribute to developing teachers' pedagogical substantive knowledge in general, and that of teachers of biology in particular, showing how the teaching-learning methods can be changed in a school system, and thus improving students' self-regulation ability in learning and their motivation, as well as changing their attitudes towards studying biology.

The present study has practical implications in the field of education:

- We recommend that the PBL method be introduced into the school system, but enough time must be allocated for its implementation, because the changes that this method can bring about take time.
- Proper training: We recommend workshops and refresher courses for teachers in order to effectively use this method of learning.
- We recommend that the method be used already at a young age, in order to develop the needed knowledge, learning, and teamwork habits and skills as early as possible.
- We recommend that appropriate teaching materials be prepared and that these strategies be introduced into a syllabus.

The study's limitations are as follows:

- The sampling method was not random, being based only on accessible classes (convenience sampling).
- All the participants were from northern Israel, so that the results cannot be generalized to the entire population in the Arab sector in Israel.
- Questionnaires in general may be perceived as too long, and could cause the subjects to become tired, which may cause them to answer automatically without reflection, thus biasing the study results.
- The present study is partly based on student reports. In-class observations would possibly have elicited more reliable information.

Recommendations for further research:

- In the present study we did not examine the teachers' motivation. It is therefore recommended to study the differences in student motivation between the two learning methods as well as to study the teachers' motivation and how it affects student motivation.
- It is recommended that in-depth interviews be held with the teachers as well. Such interviews can provide a better picture and a more profound understanding of the various factors that affect the development, promotion, and advancement of PBL among students.

The findings of the current study provide empirical evidence and a basis for concluding that applying PBL activity had a significant effect on students in terms of their motivation and positive attitudes towards biology. The PBL technique provides learners with an opportunity to actively construct their own knowledge. Since motivation and attitude are keys to learning new knowledge, this technique should be employed in teaching science areas that are poorly performed by students. Moreover, teachers should also be supported in creating PBL. Moreover, in-service training based on PBL should be given to the teachers. In the education faculties, PBL should be emphasized effectively.

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