



Received: 06 February 2016  
Accepted: 03 June 2016  
Published: 27 June 2016

\*Corresponding author: Olzan Goldstein,  
Research Department, Kaye Academic  
College of Education, Beer-Sheva, Israel  
E-mails: [olzang@kaye.ac.il](mailto:olzang@kaye.ac.il),  
[olzang@gmail.com](mailto:olzang@gmail.com)

Reviewing editor:  
Stuart Bevins, Sheffield Hallam  
University, UK

Additional information is available at  
the end of the article

## TEACHER EDUCATION & DEVELOPMENT | RESEARCH ARTICLE

# A project-based learning approach to teaching physics for pre-service elementary school teacher education students

Olzan Goldstein<sup>1\*</sup>

**Abstract:** This paper describes the impact of the project-based learning (PBL) approach on learning and teaching physics from the perspective of pre-service elementary school teacher education students and an instructor. This approach promoted meaningful learning (mainly in the scope of projects), higher motivation, and active involvement of students in learning during the entire course. It improved students' attitudes towards learning physics, reducing fear, and increasing their self-efficacy and enjoyment of learning. This approach developed essential learning and collaborative skills, and strengthened interpersonal and intercultural interactions among all. Implementing PBL raised several challenges: the tension between the quality of learning and the scope of the course content and the necessity to combine a variety of teaching methods to meet students' learning needs. The paper describes advantages and difficulties from the perspectives of both students and the instructor.

**Subjects:** Classroom Practice; Education Studies; Educational Research

**Keywords:** PBL; teaching physics; pre-service teachers; teacher education

### ABOUT THE AUTHOR

Olzan Goldstein is the head of the Research Department at Kaye Academic College of Education and the head of the intercollegiate research network "ICT integration in Israeli Teacher Education colleges" at the Intercollegiate Center for professional development of teacher educators (the MOFET Institute, Tel-Aviv, Israel). Her research interests focus on the innovative integration of pedagogy and ICT in teaching and learning, evaluation of ICT integration in teacher education, and implementation of innovations in organizations.

### PUBLIC INTEREST STATEMENT

The traditional teacher-centered lecturing approach allows for the delivery of information to large classes and can be considered cost effective in higher education. Unfortunately, such passive learning results in unsustainable outcomes: students are not motivated to learn, they do not create a meaningful knowledge base, and forget much of the course material shortly after the exam. Project-based learning (PBL) is a constructivist approach that emphasizes inquiry-based active learning which takes place through collaborative group interaction and results in valuable outcomes. The manuscript describes the impact of the project-based learning (PBL) approach on learning and teaching physics from the perspective of pre-service elementary school teacher education students and an instructor. This approach improved students' attitudes towards learning physics, reducing fear, and increasing their self-efficacy and enjoyment of learning. Implementing PBL raised several challenges. The paper describes advantages and difficulties from the perspectives of both students and the instructor.

## 1. Introduction

The traditional teacher-centered lecturing approach allows for the delivery of information to large classes and can be considered cost effective in higher education. Unfortunately, this passive learning—as a rule—results in unsustainable outcomes: students are not motivated to learn, they do not create a meaningful knowledge base, and forget much of the course material shortly after the exam. Project-based learning (PBL) is a constructivist approach that emphasizes inquiry-based active learning which takes place through collaborative group interaction and results in valuable outcomes, meaningful for the learners as well as for the society (Krajcik, McNeill, & Reiser, 2008). Students are involved in learning authentic themes, asking questions, raising hypotheses, searching for relevant information, planning an inquiry, collecting data, thinking critically, discussing, sharing ideas, reasoning and decision-making, developing a product, and presenting it to an audience. This process results in meaningful learning. The main characteristics of PBL are the centrality of PBL to the curriculum; long-term inquiry-based learning driven by meaningful, authentic questions; autonomous and collaborative learning; and a well-designed product (ibid.; Roessingh & Chambers, 2011). Planning PBL activities require from a teacher the designing of a good driving question that is not directed to predictable answers but can trigger an in-depth research process of multifaceted topics relevant to students. The teacher needs to develop an assessment process, plan activities, and the type of desired product.

The PBL approach has its theoretical roots in Dewey's (1938) ideas that teaching should focus on guiding a self-directed intentional inquiry of real-world issues as well as Vygotsky's (1978) ideas about the importance of social interaction in the learning process. The advantages of the PBL approach in teaching are enormous (Holm, 2011): (1) students develop motivation and take responsibility for their learning; (2) they create their knowledge and understanding in an integrative manner; (3) the knowledge is sustainable over a long period of time; (4) students learn to communicate through problem solving; (5) they experience a variety of learning tasks; and (6) they get a response to their learning needs. The positive impact of the PBL approach on K-12 students' achievement is confirmed by their success in entering higher education institutes (Hong, Yam, & Rossini, 2010). Along with the advantages, the approach also has a number of challenges: (1) it requires from the instructor a higher degree of professionalism and deeper content knowledge; (2) it requires much effort from both the instructor and the students; (3) PBL assignments can take a long time to complete; (4) class management is more complex than in traditional direct teaching; (5) the students need to be guided in a way that does not inhibit inquiry; and (6) students might feel less comfortable in a classroom with a PBL approach than in a traditional classroom (Dickinson & Summers, 2010).

Several studies have reported on the impact of the PBL approach on pre-service teacher training (Baran & Maskan, 2010; Dickinson & Summers, 2010; Holst, 2003). Holst (2003) explored PBL implementation in teaching an ESL course for pre-service teachers in Singapore. He reported that the future teachers enjoyed the creative process and challenges; they valued the opportunities for peer interaction; the classroom climate changed, becoming enthusiastic and friendly; cognitive learning was meaningful; participants improved their research, collaborative, speaking, and leadership skills.

## 2. The study

This paper describes the transition of the course "Fundamentals of Physics" from teaching in a traditional manner to the PBL approach. This is a compulsory two-semester course delivered to elementary school teacher education students (hereafter: students) in a college of education in Israel. In the past, this course was taught using a traditional teaching approach that included lectures, working with textbooks, solving exercises, and laboratory classes. The assessment was based on written reports of laboratory experiments and exams. Usually, the students perceived the course as difficult, expressed a lack of motivation to learning physics, and experienced a fear of the examination. The negative attitudes of the students to studying physics as well as their low achievements created the instructor's dissatisfaction in teaching the course. To promote meaningful learning, she decided to implement a PBL approach in teaching the course, and to explore its impact on the students' attitudes and learning outcomes. During the first semester, students learned Mechanics and

during the second semester, Electricity. Three or four lessons in each semester were devoted to becoming familiar with the basics of the field in order to prepare students for the inquiry activity. In the following seven lessons, they worked on their projects under the instructor's supervision. The last three lessons of the semester were left for presentations and discussion. The main objective of the projects was to develop students' ability to explain natural phenomena or principles of action of modern devices based on the laws of physics.

The PBL tasks were designed to move progressively from simple to more complicated. In the first semester, students were asked to choose a ready-made video clip from YouTube relevant to the field of mechanics and then create their video clip with an explanation of the physics of the phenomena. These clips were uploaded to YouTube and published in an intercollegiate professional social network of Israeli teacher educators.

Over the past few years, YouTube has become a powerful repository of attractive learning materials. Unfortunately, school and college students in Israel do not always benefit from these materials due to their insufficient competency in the English language. Hence, the course outcomes will contribute to building an intercollegiate video repository of learning materials in both the Hebrew and Arabic languages, thus being valued by the community of physics teachers and students in Israeli schools and colleges.

During the second semester, students created and constructed toys and instruments using ready-made kits with accompanying videotaped demonstrations and explanations of physical aspects of the way the instruments and toys worked. These PBL tasks required inquiry into unfamiliar topics in physics and higher order thinking skills (analysis, comparison, interpretation, and synthesis) as well as advanced technological skills, such as the downloading of videos, the use of screen capture tools, and the editing of video clips. Students worked in groups of 4–5 participants. The assessment of these projects included formative components (the instructor's feedback on intermediate project outcomes), and summative components, such as the final project and exam. The role of the exam was to give students an overall holistic view of the subject being studied. The exam was not an obligatory part of assessment. Its weight in the final grade was defined as 20% in order to minimize fear. The assessment also involved collaborative work evaluated through peer feedback.

The study focused on the following research questions:

Research question 1: How did PBL influence students' perceptions of teaching and learning physics?

Research question 2: What advantages of PBL did students and instructor discover?

Research question 3: What challenges did they encounter in the course?

### **3. Method**

The study was conducted using the qualitative phenomenological (based on Grounded Theory, Glaser & Strauss, 1967) approach. It had components of self-study research aimed at studying professional practice settings to understand the process of implementing a new teaching approach and improving practice (LaBoskey, Loughran, & Hamilton, 2004; Pinnegar, 1998). The major purpose of the study was to discover main issues arising from the first experience of the instructor and her students in a new unknown and uncomfortable "zone." Deep reflection on the teacher's first trial has meaningful impact on transferring tacit knowledge to explicit. In addition, quantitative data were collected that served mainly for triangulation with the conclusions of the qualitative analysis.

#### **3.1. Participants**

The sample included 23 elementary school pre-service teachers from the Teacher Education College in the South of Israel: 18 Bedouin and 5 Jewish students. All participants were female students between the ages of 19 and 30. They were enrolled in a compulsory two-semester physics course.

### 3.2. Instruments

The data were collected using the instructor's journal written during the course, two questionnaires, semi-structured interviews with course participants, and their feedback on the course. The use of various instruments was useful for the triangulation of the data (Olsen, 2004). The instructor documented the teaching process, the events that took place during the course, the students' responses and communication, her reflections, thoughts, and insights related to teaching. The questionnaires were devoted to gathering background data regarding students' previous experience in learning physics and the impact of PBL on their attitudes and perceptions of learning and teaching. The first questionnaire (Appendix 1) included six questions. Two closed questions asked for an opinion about the relevance of learning physics for elementary school teachers and students' previous experience in PBL. Four open-ended questions focused on previous experience in learning physics at school (in Israel, physics is not a compulsory subject in high school), students' preferred learning and teaching ways of this subject, students' perceptions of collaborative group work, and the success factors in collaboration. The second questionnaire (Appendix 2) included seven questions. Two closed questions related to the degree of matching the PBL approach to students' learning styles and students' opinion regarding the impact of the preparation for the final exam on creating an overall picture of the subject matter. Five open-ended questions asked about the impact of PBL on students' attitudes towards learning physics, what they liked and disliked in the course, the relevance of acquired technological skills for their teaching, and students' perceptions of collaborative work. Both questionnaires were administered anonymously using an online survey: the first was given at the beginning of the first semester (November 2011) and the second at the end of the second semester (May 2012). The interview (Appendix 3) was designed for a deeper understanding of students' responses to the open-ended questions included in the second questionnaire. It also included questions about recommendations for the instructor and students. The interviews were conducted by telephone after participants completed all course obligations (August 2012). In order to reduce a tendency of research subjects to answer in a way that they believed was more desirable for the interviewer, the interviews were conducted by a research assistant. For interviews, five students were chosen randomly by the assistant (those who responded first to a telephone call). All responses were recorded and transcribed verbatim. The data were analyzed by the author (who was also the instructor of the course) using Atlas.ti software for the content analysis of interviews, answers to open-ended questions within the questionnaires, students' feedback and the instructor's journal, and SPSS software for statistical analysis. The qualitative analysis was based on the grounded theory approach (Glaser & Strauss, 1967). It began with the textual analysis: the data were read for identifying meaningful quotes followed by open coding. After a pilot analysis of approximately one-third of the materials, the list of codes was reviewed to clarify the meaning of the codes and make samples for each code. A new list of codes was used for coding all the materials. Finally, the axial analysis (i.e. the analysis on the conceptual level) was performed using network maps to identify commonalities and relations between the codes. To avoid subjectivity and assess the reliability of the qualitative analysis, the researcher discussed results with a colleague who has experience in qualitative analysis and who had also begun teaching using the PBL approach.

### 4. Findings

A description of the findings is divided into two parts: findings related to the perspective of students and those related to the instructor.

#### 4.1. Findings: students' perspectives on learning physics using the PBL approach

##### 4.1.1. Pre-service teachers' perceptions of teaching and learning physics at the beginning of the course

At the beginning of the course, the students were asked whether they thought that elementary school teachers should learn physics. About 82% of respondents agreed with this statement. Regarding their previous experience in learning physics, 35% responded that they had not learned physics previously, 47% had taken a general course in middle school, and 18% had studied in a special program in high school. Another question dealt with a description of students' preferences in

learning and teaching physics. About 60% of the respondents expressed a preference for learning through videos, demonstrations, and experiments, 15% preferred learning through exercises, 15% desired to be taught at a slow pace, and one of the respondents noted collaborative learning as preferable.

#### 4.1.2. *The contribution of PBL to students' self-efficacy and motivation in learning physics at the end of the course*

Almost all the students (about 90%) expressed a feeling of improvement in their perceptions of learning physics due to their experience with PBL. In their responses to the open-ended questions, almost all the students expressed positive changes about learning physics. Most of the students said they feared studying physics at the beginning but during the course found it interesting and fun. Below is a typical response to the question "Has your relation to studying physics changed over the course? If so, how?"

My attitude towards physics has changed—it improved significantly compared to the beginning of the course. Self-learning, searching relevant resources, working in groups—all these empowered me professionally and helped me understand my environment.

Not one student expressed a negative attitude regarding learning physics.

The assessment of learning was based on formative assessment and summative assessment of the project outcomes. To ensure that students integrated all of the content learned in the course, they were also given a test. Another objective of the test was to evaluate the student's knowledge in order to determine the effect of the PBL approach. Despite its relatively low weight in the overall grade (20%), students were still worried. It was, however, surprising to find that they appreciated the contribution of the exam in acquiring an overall view of the subject area. Seventy Five percent of responses to the question "To what extent did preparing for the exam contribute to your overall knowledge of physics?" indicated a significant contribution.

#### 4.1.3. *Advantages and challenges of PBL from the students' perspectives*

Most of the respondents pointed out that PBL approach matched their preferred learning styles: 84% of the respondents pointed out the high degrees of suitability while the rest were neutral regarding the match.

In the responses to an open-ended question that dealt with what they liked about the course, students pointed out different aspects: a new approach, collaboration, self-learning, an opportunity to publish outcomes on a professional network, and the acquisition of technological skills (Table 1).

When asked about the benefits of collaborative learning, almost all respondents (84%) noted that it had a positive impact. This contribution was reflected in: respect for others (*Teamwork helped me in respecting others and cooperating*), productive peer learning (*When we worked as a team, I learned a lot from other students*), exposure to a variety of views, mutual support (*There are things that I do not understand, like calculations, and my partner was good at it, so we had no problem*), strengthening the contact with peers (*It improved social relationships*), and familiarity with another culture (both Jewish and Bedouin students participated in the course).

Interviews with students revealed that the main perceived benefit of PBL was a meaningful learning experience that took place in respect to their own project. Typical responses included:

You learn better when you yourself are investigating and then you remember it. I will never forget what I learned in my project! I chose a topic that interests me and I worked on it.

A list of advantages mentioned in the interviews included: investigating, searching for materials, remembering better, deeper understanding, internalizing, being able to choose topics, meeting

**Table 1. The results of qualitative analysis of the responses on the open question “What did you like in the course?”**

Category	Percent (%)	Examples of the responses
A new approach	25	I liked the teaching and learning methods—they were new for me
Collaborative learning	25	I enjoyed collaboration and liked working with a partner
Self-learning	15	It was amazing to work by myself creating something special and interesting
An opportunity to publish outcomes on a professional network	25	Preparing a video, posting it on a social network—I liked that
Acquisition of technological skills	15	I liked creating online presentations using advanced technological skills

learners’ needs, lack of pressure of assignments and exams, learning throughout the year and not just for a test, interesting, fun, collaborative work, peer learning, the instructor’s individual help. Some of students emphasized acquiring skills, such as producing multimedia-rich learning and teaching materials, effective presentations and teaching skills.

One of the students responded in the interview:

During each semester we worked on one project: we examined sites to answer the questions we raised, did research, learned, and produced videos. Each group undertook a particular project, and other groups learned from them. At the end of the year, we felt we had really mastered the material because we learned throughout the year, not just two days before the test. It was fun and interesting.

The common disadvantage of the PBL approach (in the way it was implemented in the course), mentioned by students concerned the shallow learning of topics presented by other groups. One respondent expressed her opinion:

I understood everything in my project but did not learn much from my peers’ presentations.

In addition to the difficulties associated with understanding peer presentations, students pointed out the following challenges: difficulty in understanding material unfamiliar to them; language difficulties expressed by (1) avoiding the use of information sources in English (due to a lack of language competency) and (2) presenting in a non-native language (mentioned by Bedouin students whose native tongue is Arabic and the course is held in Hebrew); difficulties in team work caused by an unequal work division among group members; and lack of time. The course participants were asked to give recommendations for the improvement of the course. They suggested giving greater weight to the basic lessons and including them in the assessment, requiring the reading of the course textbook and allocating more time to the presentations of the projects.

The learning experience with PBL also had an impact on the pre-service teachers’ attitudes towards implementing the PBL approach in their own teaching practice. Three student teachers expressed willingness to teach using this approach but pointed out that they needed to learn more about it before using it in their own classes.

#### **4.2. Findings: the instructor’s reflections on teaching with PBL**

An analysis of the instructor’s journal identified the following issues: the essence of learning (deep vs. surface learning) and the comparison of students’ learning behavior and outcomes with previous courses taught using a traditional approach; the sequential order of learning topics; the quality of outcomes and scope of the projects; the working process; teamwork; the instructor’s role and her

involvement in the students' self-directed learning process; workload; difficulties; satisfaction factors; technology and framework of the course.

#### 4.2.1. *The essence of learning*

The essence of learning attracted special attention. The questions asked in this context were: *What and how do students learn in the course? Is this meaningful learning? How does it differ from previous courses taught in a traditional way? What have students gained by the end of the course?* On the one hand, students were unfamiliar with some basic concepts; hence three traditional lectures at the beginning of course were devoted to learning basic content (concepts and physical laws). On the other hand, even though a variety of instructional materials were used to do this, it constituted passive learning and students had difficulties internalizing this background content. Although the instructor had had similar doubts in previous years when the course was taught in a traditional manner, trying a new approach explicitly revealed the disadvantages of direct teaching. When work on the projects had begun, the learning behavior of students changed: most of them were motivated and their engagement in learning increased.

#### 4.2.2. *Insufficient basic knowledge*

Another issue arose due to the students' insufficient basic knowledge. Students were expected to choose a video (from YouTube) showing interesting phenomenon and explain it using physical laws. Due to their limited subject knowledge, it was difficult for them to find a relevant video. After several attempts, some of them felt frustrated and asked the instructor to give a list of recommended videos.

In teaching and learning physics, the sequence of topics is important since usually a new topic is based on knowledge of the previous ones. For example, electromagnetism is based on knowing the basics of electricity and magnetism. Some projects (i.e. principles of electromotor) required advanced knowledge far beyond the ability of students to understand the entire complexity of the phenomenon. Hence, the instructor's involvement was necessary.

#### 4.2.3. *Learning outputs*

Learning outputs were also frequently mentioned in the instructor's journal. Students spent several lessons in class working on their project. In addition, some of the lessons were devoted to teaching technology and project presentation; hence the obligatory content of the course decreased. This caused tension between the quality of learning (due to PBL) and the scope of the course material. In the instructor's mind was the question, *"Is PBL always worth the tension it creates?"* In the case of primary pre-service teachers who do not actually teach physics, this compromise may be acceptable. But in a physics course designed for junior high school pre-service teachers (who perhaps in the future will teach physics), it seems that the instructor's commitment to the content needs to be greater.

Inequality in the scope of a project was another issue related to learning outcomes. Some groups chose rich themes and their projects forced them to learn new concepts to explain phenomena. Other groups focused on simple demonstrations of physical laws that had already been explained in the video they had chosen from YouTube. In such cases, the instructor should recommend additional topics.

#### 4.2.4. *Working process, assignments, and teamwork*

The instructor frequently related to students' progress in their work on projects. She was challenged by the necessity of defining assignments in a most detailed manner, especially in the first semester. The work involved in a project is divided into a number of stages that should be clearly defined. Since it was not clear how much time was needed for each stage and how the students would cope with the tasks, the question of whether it was fair to require certain specific tasks was raised. The instructor discussed this with students and changed requirements in accordance with considerations

raised. The second semester became easier as the instructor was already conscious of students' attitudes towards PBL as well as acquainted with the students' abilities.

The instructor noted interesting observations about teamwork. During the first semester, students worked in pairs. The instructor discovered that even in pairs, some students were passive and did not contribute to their teams. In the second semester, students were expected to work in groups of four, hence it was important to avoid the problem of unequal teamwork. At the beginning of the second semester, this problem was discussed in class and all teams agreed to undertake an obligation to support the learning presence of each teammate. This significantly improved the students' responsibility to their teammates.

#### 4.2.5. *The instructor's role*

The project-based approach prompted questions about the instructor's role. The instructor wondered about the extent of her involvement in the learning processes of the students and the boundary between facilitating learning and individualized instruction:

Today, each group worked on explanations of phenomena. Some of them searched for materials, some found resources but had difficulty understanding them while some did not find relevant sources. I worked with groups individually: explained the concepts they had trouble understanding, recommended relevant sources, helped with explanation flowcharts and helped edit their presentations. The question I'm asking myself is "Is that a kind of self-learning or is that direct instruction?"

Another question related to the instructor's responsibility for the quality of the projects posted on the professional network. Projects were devoted to serve the needs of pre-service and in-service teachers as well as school pupils, thus contributing to community. It is indeed the instructor's role to check all projects carefully and recommend to students how to improve their outcomes. This required several stages of critiquing and interaction back and forth between the instructor and students. Some of the students benefited from this but some did not relate to the suggestions and returned their products unchanged. The instructor wondered whether these unfinished projects should be uploaded to the communal network. Additional roles of the instructor discussed in the journal related to the need of giving an immediate response to students, writing a detailed description of tasks and preparing guidance materials for using technological tools.

#### 4.2.6. *Workload*

PBL is accompanied with a higher workload for the instructor. During the first semester, the class was divided into nine groups and in the second semester, into six groups. In the stage of self-learning, when individuals needed the instructor's guidance, it was impossible to work with all the groups during the lesson. Also, occasionally, the students were hampered by classroom noise which hindered both concentration and recording the speech segments in the videos. These situations forced the instructor to schedule additional meetings with the students between lessons. Another reason for the high workload was the frequent electronic communication between the students and the instructor, especially in the advanced stages of working on the projects.

#### 4.2.7. *Difficulties*

Concerning difficulties mentioned in the journal, the instructor related more to the students' difficulties and less to her own. The students' difficulties included choosing relevant videos, understanding the phenomena shown in the videos, the avoidance of reading textbooks, language problems (lack of fluency in English for reading materials online; expressing ideas and writing in Hebrew was a particular problem for the Bedouins), insufficient collaboration and presentation skills, and work overload. The instructor suggested ways of coping with these difficulties during parts of lessons that were devoted to discussing problems and looking for their solutions.

#### 4.2.8. Satisfaction factors

The journal analysis identified four major satisfaction factors of the instructor. First, the instructor felt pleased that the course changed the students' attitudes towards learning physics, and that it developed their curiosity and enjoyment of learning. This was particularly noticeable in the second semester when students built devices based on kits and learned the principles of their operation. The students actively engaged in learning and enjoyed it. Secondly, the course developed important skills: self-learning, collaborative skills, and informational and technological literacy. Thirdly, the PBL approach strengthened the personal and social relationship among the students. The cooperative atmosphere during the lessons and the individual guidance by the instructor contributed to the development of personal relationships with the students. Finally, the course can serve as a model for integrating the PBL approach in teaching; three course graduates expressed their desire to adopt this approach in teaching.

### 5. Discussion

This study explored the impact of PBL on teaching and learning physics in the course "Fundamentals of Physics" delivered to elementary school pre-service teachers. Summarizing the findings of this impact, and reflecting the perspectives of both students and the instructor, we conclude:

- The PBL approach promoted meaningful learning (mainly in the scope of projects), higher motivation, and active involvement of students in learning during the entire course. It improved students' attitudes towards learning physics, reducing fear, and increasing their self-efficacy and enjoyment of learning.
- PBL developed learning and collaborative skills as well as ICT literacy. The importance of these skills was emphasized by the national program launched in Israel in 2010 (Israel, 2011) which aimed to transform the educational system to meet the demands of the 21st century. These skills will serve students in other fields of specialty as well after they complete the course.
- This approach strengthened interpersonal and intercultural interactions among all participants and made a positive impact on the social climate in the class.

From the instructor's perspective, the trying-out of a new approach caused a reconsideration of her previous experience in teaching the course and she had the opportunity to compare the outcomes, benefits, and challenges of both approaches.

Teaching and learning with PBL have several challenges. Self-directed learning takes a long time; hence, the scope of the content cannot be identical to the content in a course designated for traditional direct teaching. In this way, meaningful learning takes place at the expense of the scope of the content. The tension between quality and scope is further complicated by an obligation to a syllabus approved by the Higher Education Council (HEC). This implies that there must be a change of policy and regulations needed for implementing PBL on the college and the HE levels. The tension between the quantity and quality of learning is discussed in the literature, especially in relation to the Singapore Education System's national initiative "Teach Less, Learn More (TLLM)" launched in 2004 (Tan, 2007). This initiative aimed to enhance student-driven learning and accordingly transform teaching and assessment methods. TLLM perceived this as a radical change that requires alternatives to high stakes examinations and tests. Another tension revealed in the study concerns the instructor's role and the boundary between facilitating learning and individualized instruction. Although PBL creates the opportunity to raise intrinsic motivation for learning, students may be frustrated by a gap between their current knowledge and the competency level needed for self-directed learning. According to Vygotsky's (1978) concept of the zone of proximal development (ZPD), a distance exists between what learners can learn by themselves and what they cannot learn without help or scaffolding. This distance may be significant when learners encounter a new discipline with its specific language and concepts. Instructors should be aware of the ZPD, and their role is to find an effective combination of different types of learning.

The research concerns examining the first steps in implementing the PBL approach. Hence, it reflects the most important and interesting stage of a change process from well-known teaching methods to new methods.

Conceptualizing experiences at this stage allows for revealing the transformation of the instructor's professional identity in all its complexity and ambiguity (Ohashi, Kurata, Sasaki Star, & Hori, 2011; Shim & Roth, 2007). The findings can contribute to instructors who are interested in trying PBL or other new teaching approach for them. They may also contribute to understanding the possible behavior among students when they try to learn through PBL.

### 5.1. Limitations of the research and future directions

Despite the contribution of the research to the body knowledge about first steps in implementing the PBL approach in teaching physics, it has limitations. The research is based on self-reported data by the students and the instructor; hence, it reflects subjective personal opinions of informants. Although the questionnaires were filled out anonymously and the interviews were collected by a research assistant after the respondents received their final grades, there may be a possibility of social desirability. Another limitation concerns the small number of participants in the research. Perhaps the sample's diversity in different parameters (such as learning styles or attitudes towards learning physics) did not represent the existing diversity among a larger population. Also, there is a limitation regarding the quantitative part of the research. The questionnaires included mainly open-ended questions and were devoted to exploratory research revealing major issues that arose throughout the course. It is clear that the research results do not aim at generalizing to a larger population.

## 6. Summary

The research identified essential issues which came up in the PBL process that can help to build quantitative pre-post instruments for measuring the impact of PBL on different aspects of students' learning and social behavior. Future research will focus on such an evaluation regarding new cohorts of students and will follow those students who graduated and are teaching.

### Funding

This work was supported by Kaye Academic College of Education.

### Author details

Olzan Goldstein<sup>1</sup>

E-mail: [olzang@kaye.ac.il](mailto:olzang@kaye.ac.il)

<sup>1</sup> Research Department, Kaye Academic College of Education, Beer-Sheva, Israel.

### Citation information

Cite this article as: A project-based learning approach to teaching physics for pre-service elementary school teacher education students, Olzan Goldstein, *Cogent Education* (2016), 3: 1200833.

### References

- Baran, M., & Maskan, A. (2010). The effect of project-based learning on pre-service physics teachers' electrostatic achievements. *Cypriot Journal of Educational Sciences*, 5, 243–257.
- Dewey, J. (1938). *Experience and education*. New York, NY: Collier Books.
- Dickinson, G., & Summers, E. J. (2010). *Understanding proficiency in project-based instruction: Interlinking the perceptions and experiences of preservice and in-service teachers and their students*. Retrieved from [http://www.bobpearlman.org/newtechfoundation/Research/ManorReport\\_UT\\_SanMarcos\\_ejs&gd1.pdf](http://www.bobpearlman.org/newtechfoundation/Research/ManorReport_UT_SanMarcos_ejs&gd1.pdf)
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine Publication Co.
- Holm, M. (2011). Project-based instruction: A review of the literature on effectiveness in prekindergarten through 12th grade classrooms, *InSight: Rivier Academic Journal*, 7(2), 1–13.
- Holst, J. K. (2003). Implementing project-based learning in pre-service teacher education. Retrieved from <http://www.hersa.org.au>
- Hong, L., Yam, S., & Rossini, P. (2010, January 24–27). *Implementing a project-based learning approach in an introductory property course* (pp. 1–19). Wellington: Proceedings from the 16th Pacific Rim Real Estate Society Conference.
- Israel, M. O. E. (2011). Adapting the education system to the 21st century: The national plan, The official site of Israel ministry of education (Hebrew). Retrieved from: <http://cms.education.gov.il>
- Krajcik, J., McNeill, K. L. M. C., & Reiser, B. J. (2008). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. *Science Education*, 92(1), 1–32. [http://dx.doi.org/10.1002/\(ISSN\)1098-237X](http://dx.doi.org/10.1002/(ISSN)1098-237X)
- LaBoskey, V. K., Loughran, J., & Hamilton, M. L. (2004). The methodology of self-study and its theoretical underpinnings. *International Handbook of Self-study of Teaching and Teacher Education Practices*, 2, 817–869. <http://dx.doi.org/10.1007/978-1-4020-6545-3>
- Ohashi, M., Kurata, N., Sasaki Star, K., & Hori, M. (2011). On the study of knowledge structuralizing and adaptive processes based on project based learning. In C. Ho & M. Lin (Eds.), *Proceedings of e-learn: World conference on e-learning in corporate, government, healthcare, and higher education* (pp. 2229–2235). Chesapeake,

VA: Association for the Advancement of Computing in Education (AACE).

Olsen, W. (2004). Triangulation in social research: Qualitative and quantitative methods can really be mixed. In M. Holborn (Ed.), *Developments in sociology* (pp. 1–30). Ormskirk: Causeway Press. doi: <http://dx.doi.org/10.1002/jhbs.20022>

Pinnegar, S. (1998). Introduction to part II: Methodological perspectives. In M. L. Hamilton (Ed.), *Reconceptualizing teaching practice: Self-study in teacher education* (pp. 31–33). London: Falmer Press.

Roessingh, H., & Chambers, W. (2011). Project-based learning and pedagogy in teacher preparation: Staking out the theoretical mid-ground. *International Journal of Teaching and Learning in Higher Education*, 23, 60–71.

Shim, H. S., & Roth, G. L. (2007). Sharing tacit knowledge among expert teaching professors and mentees: Considerations for career and technical education teacher educators. *Journal of Industrial Teacher Education*, 44, 5–28.

Tan, K. H. K. (2007). *Is teach less, learn more a quantitative or qualitative idea?* (pp. 1–17). Singapore: Proceedings of Redesigning Pedagogy: Culture, Knowledge and Understanding Conference.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological process*. Cambridge, MA: Harvard.

### Appendix 1: The first questionnaire administered at the beginning of the course

Question	Responses
Do you think a teacher in elementary school should study physics?	No, Yes, Don't know
What is your background in studying physics?	Four levels: didn't study, took general course in the middle school, low-level courses in the high school, high-level courses in the high school
What do you feel regarding studying physics?	Open question
Have you had experience with project-based learning in the past?	Open question
Do you prefer to learn in a group?	Open question
In what ways would you like to study physics?	Open question
What are your expectations of your team members when learning and working together?	Open question
What is needed to be able to work as a successful team?	Open question

### Appendix 2: The second questionnaire administered at the end of the course

Responses	Question
Has your relation to studying physics changed during the course? If so, how?	Open question
To what extent does project-based learning suit your learning style?	Scale from 1 to 7
What did you like in the course?	Open question
What did you dislike in the course?	Open question
To what extent did preparation for the exam contribute to creating an overall picture of the subject matter?	Scale from 1 to 5
During the semester you created your own video and published it on a social network. Is this skill relevant to you as a teacher for the future?	Open question
Was teamwork helpful for you? How did you contribute to the team?	Open question

### Appendix 3: The interview questions

- (1) Is PBL appropriate for studying physics?
- (2) What are the advantages of the approach?
- (3) What are the disadvantages of the approach?
- (4) Did PBL increase your motivation to learn physics?
- (5) What difficulties did you encounter during the course?
- (6) What would you recommend to the instructor for course improvement?
- (7) What would you recommend for students to succeed in this course?
- (8) Would you like to teach using this approach in school?



© 2016 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.



**Cogent Education (ISSN: 2331-186X) is published by Cogent OA, part of Taylor & Francis Group.**

**Publishing with Cogent OA ensures:**

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

**Submit your manuscript to a Cogent OA journal at [www.CogentOA.com](http://www.CogentOA.com)**

