## כותרת אופציונאליות

## Teachers’ Roles and Attitudes in Project-Based Learning of High-Tech Subjects

## חסר תקציר ומבוא

Project-based Learning

Project-based learning (PBL) has theoretical roots in constructivism, which views education as a natural process during which meaning is created through student interactions and reflections on ideas and experiences (Dewey, 1938). Project-based learning and problem-based learning (PBL) are often presented as preferred instructional methods for teaching science and developing students’ general skills, such as independent learning, problem-solving, creativity, metacognition, and teamwork (Barak & Assal, 2018; Crismond, 2011; Kolmos, 1996; Savery, 2006; Thomas, n.d.). PBL places learners in an environment and active role in which they undertake authentic assignments and learn through doing exercises in design and problem-solving, while applying knowledge of mathematics, physics, and programming.

Despite the broad consensus in the literature about the advantages of PBL over traditional educational methods, educators are increasingly aware of the difficulties and limitations of applying these methods in the regular school context. If the problems presented to students are too well-structured, close-ended, or simple, or, alternatively if they are too abstract and unrealistic, then students may be busy ‘doing’ while little significant learning takes place (Blumenfeld et al., 1991; Barron et al., 1998; Barak, 2013).

Booker (2007) uses the term “a roof without walls” to describe the desire to develop higher-order thinking skills (according to Bloom’s taxonomy) among children who have not yet learned facts or gained substantive knowledge in a certain subject. Dolmans and his colleagues posit that in order to stimulate students towards constructive and contextual learning, there is a need for realistic, open-ended, and ill-structured problems that fit with students’ prior knowledge (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005). These authors add that PBL curricula should begin with shared guidance of both students and tutors, and move towards greater student guidance at the end. Kirschner, Sweller, & and Clark, (2006) note the failure of constructivist-oriented instructional methods such as discovery, problem-based and inquiry-based teaching because giving minimal guidance during learning is less effective and less efficient than instructional approaches that emphasize guidance of the student learning process (Hushman & Marley, 2015). The advantage of guidance begins to recede only when learners have a sufficiently high level of prior knowledge to provide ‘internal guidance.’ Some supporters of PBL (Hmelo-Silver, 2004; Hmelo-Silver, Duncan, & Chinn, 2007; Savery, 2006; Tsybulsky & Muchnik-Rozanov, 2019) address the limitations of this method, and note that it is important to tailor the scope and complexity of the assignments to students’ prior knowledge and skills, and to provide instruction and scaffolding in order to reduce the cognitive load and enable students to learn in a complex domain.

The role of teachers who employ the PBL approach differs significantly from traditional roles focused on knowledge transfer, which require teachers to have a high degree of knowledge in several fields, management skills, and the ability to impart this knowledge to their students (Council, Education, Sciences, & Practice, 2000). From the teachers’ point of view, PBL combines innovative teaching and meaningful learning, and thus affects three aspects: personal, professional, and ecological. Educators engaged in PBL agree it involves an ongoing process of development that takes place via constant interaction between individuals and the environment in which they function (Vonk, 1995).

# The Teacher’s Role in Project-Based Learning

The role of the teacher in meaningful learning, and especially in PBL, is fundamentally different from that of traditional learning (Thomas, n.d.). From the teachers’ perspective, the projects that are part of PBL should be open-ended and integrative in the long-term. PBL is an investigation conducted in a joint framework developed in conjunction with the students’ contribution. Teachers play a vital role in the learning process in that they are responsible for creating an environment that provides opportunities for experiences and for helping students understand how to learn. Teachers need to consider and prepare themselves for the various directions students may follow, know where students can search for information, and how they can best implement new knowledge. Teachers conduct mini-lessons and conversations, choose reading materials, or write schedules for the entire class (Rose, Habgood, & Jay, 2017). Since there are multiple ways to carry out projects, teachers must approach ​​PBL, its context, and its strengths, appropriately.

This article presents a study of uses of PBL that involve few lectures by the teachers to the entire class. Instead, the teachers move between groups of students, ask questions, offer suggestions, and challenge their thinking. In the context of PBL, the teacher functions primarily as a mentor, a guide, and a resource for students.

# Teachers' perceptions of advantages and disadvantages of PBL with students

Many studies (Holm, n.d.; Tal, Krajcik, & Blumenfeld, 2006) have compared the PBL approach to traditional learning. These studies have indicated several advantages of PBL over traditional methods, including: improving students’ ability to validate reasoning with clear arguments; developing a high ability to plan a project after working on a corresponding challenging problem; improving the achievements of students who find it difficult to learn from traditional teaching methods; improving critical thinking; improving social skills; improving the field of knowledge and content; developing learning capabilities; developing group skills; improving information literacy; developing flexible and useful knowledge; and encouraging exploration and self-reflection. Findings have also shown that the PBL approach enables greater student involvement in the field of knowledge.

Teachers report that focusing on realistic problems enables weaker students to share their knowledge of the field of study. Teachers also report a reduced need for disciplinary intervention during PBL lessons, since students are much more involved in the learning process. Several studies indicate significant academic impacts evident mainly among mediocre and weaker students (Tal et al., 2006). In contrast, Tartan and Zachrius (Holm, n.d.) find that although teachers report improvement in skills such as responsibility, problem-solving, critical thinking, and collaboration, nevertheless the ability to learn new knowledge and content received the lowest score in this study. The study also indicates other disadvantages to the PBL approach. For example, during the initial stage, students do not relate to critical features of problems and do not employ effective problem-solving strategies. An additional finding indicates that the PBL approach, which places great responsibility on the student, may lead to a situation in which goals are missed and misconceptions are maintained due to the lack of strategic intervention and guidance by the teacher.

Therefore, in order to enable effective assimilation of the PBL approach within the school system, especially in terms of teachers’ attitudes towards the subject, a systemic change must occur. Such a change should provide teachers with support and the optimal conditions in order to implement the new learning approach successfully. This can be achieved when through collaboration and a commitment by the entire staff to the subject at hand. In this way, it will be possible to expand pedagogical support for teachers by providing technological support and assistance in curriculum development, making the technology a cognitive tool and not merely a study aid (Tal et al., 2006).

Systemic change, however, is not sufficient. In order to be effective, teachers must understand the concepts and ideas inherent in the project, and they must be able to demonstrate to their students the necessary thinking and problem-solving strategies in a qualitative manner. Teachers need to accomplish this task with staff training and guidance in employing PBL assimilation and work processes.

In addition, studies show that effective projects require collaboration among the school staff, as well as the development of methods to assess expected learning outcomes. Without carefully planned tasks, skilled teachers, and optimal school learning conditions, all designed appropriately to support the projects, the PBL approach may become a collection of activities without any purpose or clear outcomes (Tal et al., 2006).

The purpose of the current study is to examine teachers’ point of view regarding how professional experience and existing orientations towards teaching and learning influence their implementation of a curriculum of PBL. All teachers want their students to be successful; however, different definitions of success lead to quite different approaches towards teaching. For the most part, these differences seem to occur due to teachers’ pre-existing orientations regarding teaching their discipline. Implications for professional development taking into account teachers’ orientations and thus their professional experience are discussed, as well as disciplinary challenges to using PBL (Zadok & Voloch, 2018).

In most cases, principals prefer educators (class tutors) over professional teachers, because of the ecological orientation of educators required by the project. This orientation is manifest in the relationships among elements within the school, the community, and parents involved in the PBL projects. This can lead to a situation in which some teachers leading learning projects have the appropriate disciplinary background, such as engineering, programming, and physics, while others had no relevant background.

# Mutual creative space

Mutual creative space is a concept based on the negotiation of perceptions, beliefs, attitudes, and behaviors, including mutual learning (BenEzer, 2012). In other words, this is a way of creating a universal language. Teachers and students create this space together. A mutual creative space, as described by BenEzer (2012), can enable significant communication and a meaningful encounter between people of different cultures. In this potential space, something new is created, and participants may experience developmental growth (BenEzer, 2012). During a 'dialogic moment', a mutual creative space may be created. In this space, no one fully belongs to another, but neither are they strangers. It constitutes an opportunity to create an open and equitable cross-cultural encounter, which takes place within an unequal conflictual reality. People may address worldviews, beliefs, values, attitudes, and behaviors. It encourages multi-perspective thinking about the self and the other, thus increasing critical awareness of personal meanings (Ramaekers, 2010). The findings of this study indicate that during the project, a 'mutual creative space' can be created, which is an opportunity to create an open and equitable interactive encounter between teachers and students and among students. This space encourages a multi-perspective view of the teacher's role, allowing for a mutual enrichment.

2: Methodology

This research is based on narrative and qualitative research methods (Yosifun 2016). It is built around teachers’ life stories and the insights they provide into the ways teachers experience and explain their duties, in coordination with their decision-making processes and their interactions with their environment.

Choice ofssare

Research questions

The current study addresses two research questions:

Question 1: What are the characteristics of the learning and teaching processes in courses that follow a PBL curriculum in junior high schools?

Question 2: How do teachers do who teach using the PBL method evaluate its contribution from individual, professional, and ecological perspectives?

2.2 Research tools

The research is based on semi-structured interviews with five teachers. The interviews included open questions through which the teachers were asked to discuss their personal experiences and the ways they experienced the projects. They also included direct questions aimed at clarifying the teachers’ positions regarding the research questions. Some of the interview questions were planned and were identical for all participants, but the majority of the questions were brought up during the conversations between the interviewees and the interviewer.

2.3 The research process and the data processing

Interviews were carried out with teachers who had personal experience in the use of the PBL approach. The format of the interview included ten questions, some of which were broken down into sub-questions to enable more details and elaboration. The interviews were coordinated in advance and conducted outside the school. They each lasted approximately one hour. The interviews were recorded (on an iPhone placed on the table) and later transcribed. The purpose of the interview was first explained to the teachers two weeks prior to the interview in a telephone conversation, during which their consent to participate was received, and the same explanation was reiterated at the beginning of the interview.

In the empirical social sciences, qualitative interviews are a common way to collect data (Fransella, 1982), as they form a technique or method to determine or discover the interviewees’ points of view regarding events that differ from those of the researcher (the interviewer) (Bauer & Gaskell, 2008; Dakers, 2011).

Following the face-to-face interviews with the teachers, the recorded interviews were transcribed and the written texts were analyzed using software (<https://atlasti.com>) that indicates repeated words and phrases in the interviews. Based on these, the main themes of the research were identified. The themes were split into two parts: six categories related to the first research question, and three related to the second.

2.4: Ethics in the research

In order to ensure adherence to ethical standards and the credibility of the research, strict procedures were followed. First, all participants gave informed consent to take part in the research, following a full explanation on the objectives of the research and research questions. Second, we made an effort to honor the privacy of the participants and changed all identifying data. Third, all data collected in the research were safeguarded in a way that ensured full secrecy and privacy of personal information, as required for an ethical research project.

2.5: Validity and reliability of the research

Qualitative studies are based on the investigator's interpretation of the questions under investigation, and on spontaneous conversation between the researcher and the research participants; therefore, the ability to test the validity of the research or to recover its results is limited. However, combining the interviews with the research itself will allow for this difficulty.

Furthermore, to ensure the reliability of the research, the most complete possible presentations of the participants' responses are included, to enable readers to access them in a precise way, and determine if they interpret them in the same way as the researchers do.

2.6: Research population

The study population consisted of six teachers who had experience with PBL during the previous year. We selected the respondents for the study based on their relationship to the case study. All names are pseudonyms.

**Firuz**. The first interviewee is a young teacher from the Arab sector, with a degree to teach English studies. Firuz has been teaching English for two years. She feels that everything is new to her; teaching, project guidance, and classroom education. The project guidance came in response to a request from the principal who was looking for "motivated young people with or without a teacher's certificate with an understanding in the field of computers and technology which is not necessarily their area of ​​expertise is computers”. According to her, the project is a childhood dream. She says: "When we were students, we were fed up with numbers and accounting, enough with the books, we were so thirsty for something else, thinking differently, engaging in something else not just writing to read all day." For her, the project guidance was what she always dreamed of.

**Ronni**. The second interviewee is a teacher in junior high school. He is an eighth-grade homeroom teacher, 37 years old and holds an M.A. in Business Administration and a B.A. in Psychology. Also, he is a graduate of the school in which he teaches, and for him, teaching at his school is coming full circle. Ronni has been teaching for seven years. Ronni worked in the hi-tech field for many years, taught mentors, and currently specializes in PBL and classes with gifted students. When Ronni worked in elementary school, he taught using the PBL method. This is the first year he taught technology using this method. Ronni and another teacher lead classes with gifted students. Recently, the scientific staff at the school expanded; there is now a staff manager, collaboration between different classes, an afternoon class open to the public, and study-groups. In his words: “On a global scale, our school is in the lead with awards in technology and science. For us ‘The sky is the limit’”.

**Ofer**. The third interviewee has been a science and technology teacher for many years. Before becoming a teacher, he worked as a networking engineer in hi-tech companies. Ofer is dedicated to his work: “If one believes and loves what he does, that requires to put extra hours. Many times, I work eight hours even though I am paid to work for two. I do that for the kids since I know that the regular hours are never enough… I love what I do, and I have great satisfaction when I see that the children enjoy being successful and create friendships at the same time.” As part of his schoolwork, Ofer is given free rein by the school’s management: “I’m pretty independent. I work alone with the kids.” Ofer receives a lot of support and love from the kids’ parents, which gives him great satisfaction: “One mother came to me and hugged me and said, ‘What you gave to my daughter no other teacher did,’ I did not know who she was. For me, this is real satisfaction when I know that I come and have an influence not only in technology but also in terms of the students’ mind and loving and understanding what is different. That makes it worth it all. Technology is a tool that connects people.”

**Sally**. The fourth interviewee is a 25-year-old teacher in the Arab sector. Sally was previously an English teacher, but last year she studied computer science and now teaches technical algorithmic thinking skills. She has a deep understanding of computing, programming, and algorithms. She is a graduate of the School of Science and Leadership of the Arab Sector. “The principal believes in me and expect me to do a lot in this school. She gives me more motivation, a sense of satisfaction, and happiness while giving my best for the kids”.

**Ricky**. The fifth interviewee is a seven-year elementary school teacher who previously taught high school computers at another school. Ricky holds several academic degrees and moved from the high-tech world into teaching. In agreement with the school's management, she went on to study and so Ricky is now a leading and influential force in this field. She sees this project as a mission: "the project has become my baby in this school; this is a serious part of my life."

**Ofra**. The sixth interviewee has taught science for many years. She graduated with degrees in biology, ecology, and environmental studies, and after many years working in those fields transformed to teaching. Ofra has taught at the school for 12 years, where she has led the field of technology for ten years. For her teaching using a PBL method: “It is a celebration, it is very family-oriented,” she says: “The parents are very involved.” The project and her students are a source of pride for her. She believes that everything a person does should come from a basis of enthusiasm and understanding of what it gives the teacher, “I will not lie. I benefit from this activity even when I lose sleep”. She believes that children gain tools for life that will help them in every field.

3. Findings

Analysis of the findings: The analysis of the interviews revealed six main themes by which the data was analyzed:

1. Ecological characteristics of the learning process.
2. External motivation for Project-Based Learning.
3. Creating a collaborative creative space.
4. Contribution to the school curriculum.
5. Benefits to students from co-learning in the project.
6. Teachers' assessment of the contribution of the PBL method to the ecological, personal, and professional aspects.

For each of these themes, the study presents key ideas that emerge from the data analysis as well as quotes from the interviews with the teachers.

The first research question**: What are the characteristics of the learning and teaching processes in courses that follow a PBL curriculum in junior high schools?**

In answer to this question, we found various characteristics: ecological, external, internal, characteristics of shared creative space, contribution to studies, teachers, and students.

3.1 Ecological characteristics of the learning process

One of the issues that stood out in many of the interviews about the characteristics of the school project was the perception of the project as something ecological, involving many factors in the environment and affecting them positively. There are 24 references to these issues, including responses referring to the position of the principal, the group, the parents, the educational staff, psychologists and professionals, mentors, and more. The emphasis, according to the interviewees, was that this kind of project could "Change activity to collaborate."

The principal’s involvement in the project is mentioned in quotes such as: “An active principal helps with organizing the process and optimizes it”; “She believes in us and wants us to do great things in the school” and “One of the biggest motivators for the children is the principal who took it upon herself to be an active member of the team.”

The parents’ involvement in the project can be seen in quotes from the teachers, such as: “Some parents do not leave because they are excited and having fun, and they see how this project helps them and their kids have a better relationship”; “Involving parents in this important process” or “If there is no commitment and involvement of the parents, the group will not succeed”.

Other factors involved in the process can be found in quotes such as: “We worked with a family psychologist who accompanied the group”; “The whole group wanted a mentor, which means, we taught them how to ask for help and guidance” or “I tell the teachers: ‘do not be afraid to try together’”.

Quotes about people working together to do an “ecological” project include: “I help parents, teachers, and students be responsible and we divide work between the team members”, “Collaboration and teamwork by other parties are needed, i.e., a school principal who will allow students to stay beyond the set time of learning hours, parental consent, a mentor who joins the team for the competition that will drive the project’s success,” and, “The school team has expanded. There is a field coordinator, and there is also much collaboration between the layers. It is also communal, he continues this afternoon.”

All of these quotes show how a project that involves collaborative learning is essentially characterized by combining and integrating various elements into the educational environment, so that synergy is created between the parties involved, all of whom benefit. Alongside this, external motives that characterize the project can also be seen.

3.2. The external motives for PBL

Another issue that came up in many interviews (14 times) touches on the motivations of the interviewees, all of whom are leading or otherwise taking part in a technology education project. In most cases, the attempt to promote the process could be attributed to an intrinsic motivation to contribute to the school, a personal connection to the topic, or a belief that it addresses the students' wishes. Sometimes, the principal was seen as a motivator for the process.

A deep, personal connection to the subject can be seen in quotes such as: “As a university student I was very interested in building models that can help improve the lives of elders”; “The subject excited and fulfills me, as I enjoy the children’s enthusiasm and their activities. My motivation is mainly educational” and “I started after friends invited me to come and see this project and I just had to join.”

The indirect contribution of the program to the relationship between the teacher and the school, students, and administrators can be seen in quotes such as: "This greatly contributes to the motivation that you are valuable in the school, and gives you something to do," and "I want to participate in this project every year. It's really that they have allowed me and given a stage to my project, given respect and appreciation for my work”.

Attitudes regarding the process from the students’ perspective can be learned from quotes such as: “Seeing the kids’ projects, hearing them talk, that’s what inspires, motivates,” and “It began with a fourth grade student who came and said, ‘I want to…!’ and I didn’t know why I was getting involved, but I said we would look into it, and together we formed a group. In the first two years, we learned the subject, and then it became my baby in the school”.

The school principal's role in the motivation to start a project can be seen in the following quotes: “The principal approached us. She wanted motivated young teachers who understand the field of computers and technology”; “The principal saw in you potential to do great things in the school,” and “She believes in us, and she wants us to do many things at school.”

All of these quotes indicate how a variety of external motives, such as personal interest, desire for promotion and appreciation within the school, the wants and needs of the students or the principal, will initiate the launching of a collaborative learning project. However, it can be seen that continuation of the project process was often attributed to internal motives.

3.3. The internal motives for project-based learning

At the beginning of the project, motivation resulted from a combination of several factors. There were seven references to later stages of the project: motivation, satisfaction, pride, joy, enthusiasm, and understanding.

Descriptions of these feelings among teachers as the result of PBL were repeated several times, for example: “The satisfaction is so great I don’t give up even though it’s not easy”; “First of all, I felt proud. I didn’t stand in the center of the room and talk, and I didn’t have to lead the discussion. I just stood on the sidelines”; “I feel happier and proud of them, and it is also satisfying that the project works,”; “I let the kids get to these places, and I am happy they succeed,”; “You need someone who is connected to the kids who can act differently, to say, 'Okay I’m recalculating the track. It won't be 45 minutes just because that’s what it is [supposed to be]. If it takes 3 hours, then that's what we will do,” and “I think everything you do should come based on enthusiasm and understanding of what it gives you as a teacher. I will not lie. I benefit from this activity”.

Importantly, in this context, almost all interviewees seemed to agree on the many positive feelings that they gained from the project and towards those who convinced them participate and persevere, even though they were not rewarded for it.

3.4. Creating a collaborative creative space.

Another interesting topic that the interviewees referred to is that the activity around the project blurs the clear boundaries between the teachers and the students and allows them to engage in a mutual learning processes. Additionally, in these processes, students also teach each other and serve as mentors for themselves. Collaborative learning and the development of shared creative space were mentioned 24 times in the interviews, for example: “When we are facing a problem, we discuss it and often the students will lead the discussion”; “At the beginning of the project, the students sit with the teacher and create a thinking group that aims to set a central goal for a common problem,” and “I’ve learned through it, through trial and error with the students, how to do it.”

Other interviewees described this as an authentic learning process: “The teacher becomes a student just like them,”; “I learned from them and learned much more with them than by being a teacher,” and “You can learn from the children themselves.”

These quotes show how PBL is distinctive in the development of a creative, collaborative space, in which what both teachers and students receive far exceeds their initial expectations. This stems from the teachers' knowledge as well as from the shared experiences and understandings of other students.

3.5. Contribution to the school

In some of the interviews, there was a reference to the joint learning project as one that could contribute to the school. This contribution was expressed at 14 different times, with each emphasis being on the possibility of producing a different method of measurement than usual, as seen in the following quotes: “In the classroom, I try not to be the source of knowledge but to teach them to learn and do it themselves,” ; “We want a good education, we need a different kind of education,” and, “Go out and search for those who are willing to act differently”.

Also, these processes are seen as being conducted differently, thus developing different abilities in children, as seen in the following quotes: “The classroom structure is different. The teaching style is different; the style is different, something unconventional”, “He (the student) exercised his creativity. We made him think outside the box, which is part of our goal” or “Significant learning; this is real learning; authentic learning; experiential learning.”

In one interview, a teacher concluded: “I think when the kids come into the lab or the room they work in regularly, the atmosphere is different. It should be a room that is not like a classroom, a room with an inviting environment that encourages clear thinking. Even at the level of putting rugs, sitting on the floor ... the atmosphere in the room should be different. I think creativity comes out when not sitting in a chair at a desk. In addition to having the technical means to carry out the project, whether it’s at a computer, a desk ... they found that conventional book learning was boring and while researching and meeting with knowledge experts, they develop interactive book extensions. Nothing compares to regular classroom learning.”

The capabilities that develop following these kinds of projects are described in quotes such as: “We learn that in order to reach our goal we must invest in important values such as collaboration, teamwork, professionalism and striving for excellence and success”; “a (developing) value educational approach for children” or “(developing) thinking outside the box”.

All of these quotes can teach us that through a collaborative learning project, a learning environment with a different atmosphere is developed, in which teachers take on different roles, and the abilities that students acquire are different. As a result, a contribution to both the teachers and the students can be seen.

3.6. Contribution to the student from co-learning during the project.

The final set of characteristics of the collaborative learning environment relates to students’ gains from this type of learning. Interviewees made 27 varied and extensive references to the fact that students are given very different roles in the collaborative learning environment, as responsible participants and as motivators of the process, for example: “They are children who want to learn, want to learn from themselves, their curiosity and drive for progress is within themselves,” “They bring the ideas and develop them.”

The teachers describe their own role as one of reduced involvement: “In the classroom, I try not to be the source of knowledge but to teach them to learn and do it themselves” or “in this context, they have been able to bring their knowledge because they do it in a different way”.

As a result, teachers describe students as being more successful in life: “Our children in the program have learned life tools, tools that help them in every field.”, “I can step back as they lead the process, and they will work in the future in high-tech” or “It’s an excellent way for students to acquire and master learning, research, and problem-solving skills. These skills will serve them during their studies and later on as contributing and curious citizens studying throughout their lives.”

3.7. Assessment of teachers of PBL on the contribution of learning to the ecological aspect

As mentioned in the first theme, many teachers note the significant contribution of the shared learning space to an ecological project, as shown in the following quotes:

“The parents are very involved, and we are trying to make the project a community project, to make it collaborative, to get people involved, and to show the activity”; “I see parents who do not leave because they are enthusiastic and are having fun, they see the bond created with the children. Moreover, we have a really good time”; “You are our age with small children and if you have to put songs, exceptional learning has been created besides learning more and playing with LEGOs. I see it with my mentors that it is abnormal fun”;

“The level of motivation is very high, the more they are exposed to the project and the more they get a taste of the field, the higher the level of motivation, the enthusiasm is also growing, especially among the students.” “Parents too - once they arrive and are exposed, it is enough that they come to one meeting, it gives them the feeling that ‘here I come for more’… I even had two parents who became mentors”.

These four quotes show that it is precisely the interaction between factors that do not always work together in the educational framework, and the great pleasure that all the parties take from the process, which is the main contribution of the collaborative learning project. On the other hand, other teachers emphasized the contribution to the personal aspect.

3.8. Teacher assessment the contribution of learning in the personal aspect

From a personal perspective, the project was described as giving a great deal of comfort and instilling a positive attitude among everyone involved. In some cases, it could be seen that these personal feelings are the most significant contribution of the project. One can learn from this, for example, from the following quotes: “First of all, it is the satisfaction, when they are enthusiastic. Also the quiet students who find it difficult in the science professions succeed in it ... It motivated me, gave a feeling of satisfaction, of happiness”; “It brought me back to my childhood, when we got tired of books and math, enough with the books, we were so thirsty for something else, thinking differently, engaging in something else not just writing and reading all day” and “First of all, it is pride, really and this is exactly where I did not stand and speak, and I did not lead the discussion…. I stood aside and standing aside, I am happier and proud of them. It is also satisfying that the process works….they know how to explain the problem and the solution. Moreover, they talk and understand it don’t just repeat like a parrot; they researched and solved tasks,”; “We need the curiosity, the enthusiasm, the faith. I call it faith because it is openness to try new things. We need to create this enthusiasm because if you show enthusiasm, then it can drive children to it. First I was just me, then every time I had one volunteer. I see parents who do not leave because they are enthusiastic and are having fun, they see the bond created with the children, Moreover, what a good time we have”, “you are our age with small children and if you have to put songs, Exceptional learning has been created besides learning more and playing with LEGOs. I see it with my mentors that it is abnormal fun and their friendship, and if you have to put songs and create something awful exciting other than learning and playing more, what else do you need? I see it with my mentors that it is abnormal fun.”

All these quotes indicate the contribution to the entire educational space is a primary contribution of the collaborative learning project, and that the teacher’s sense of self is also a motivator in this regard. Similarly, it can be seen that teachers personal and social contributions as well as professional contributions to the field of PBL.

3.9. Teacher assessment the contribution of learning in the professional aspect

The final theme that emerges from the interviews, and repeated several times, was that teachers see the program as providing students with extensive professional knowledge that is better suited to the 21st century compared to traditional knowledge areas taught in schools. It can be seen in the following quotes:

“We now expect students to do some programming, which includes: commands, conditions, and loops, and by the end of the year to learn what control is. You would be surprised what these students know about programming. They are not concentrated in classes, and students, no matter how proficient the teacher, is but if the teacher relates to me, sees me as successful. That is significant,”; “Active learning, inquiry-based learning, and problem-solving, peer learning and peer feedback and clear and predefined steps,”; “First of all, they put the project in school, so I think I was able to give that experience and understanding and to share with others and that led to activity in this area as well as for me personally. In the classroom, I try not to be the source of knowledge but to teach them to learn and do it themselves. It may not always be successful with 30 students, but it has changed my perception, this more pleasant method is more successful - it is true.”

These three quotes show that the collaborative learning project enables more meaningful learning processes. It gives personalized access to all students and develops these important technological skills, as a result of this contribution. Teachers value collaborative learning in general and a project in particular as having professional value, which links the ecological and personal value of the project as a total contribution.

4. Discussion

The study examines the meanings and characteristics of collaborative learning in a school project. In this regard, according to the literature, criticism of the frontal teaching method revolves mainly around the teachers’ and students’ roles. Frontal instruction, also known as the “Funnel Concept,” sees the students as receptacles for knowledge that the teacher chooses to pass on to them, without students being involved in learning-related decisions (in terms of objectives, content, means, or evaluation) (Bar-el, 1996). However, PBL, as described above, is seen by all the interviewed teachers as such a thought fixture that challenges traditional teaching concepts. Students become experts and initiators, and the teachers undergo significant learning processes.

It is essential to emphasize that even when teachers have no primary knowledge and are not “knowledge providers” it is still their responsibility to bring about their students’ success. According to Tobin (2010), the teacher is the main factor in the quality of the education system. Indeed, this study describes the extent to which these processes do occur during collaborative learning. This process shows that the teacher has many roles in the success of the project, as part of a complex environment, and needs to be involved and integrated into the creative project. When teachers do this with respect, attentiveness, and giving room to the wishes of the students, a quality process emerges, with diverse contributions on many levels. According to Assaf’s (2010) article, the teacher plays a vital role as a leader and evaluator in the framework of collaborative learning. Without the teacher’s assessment, there may be situations in which collaborative learning will be ineffective: students’ contribution to the group will be incomplete, learning outcomes will be impaired, and so on.

According to the literature, the type of teacher that increases students’ success are those whose purpose is to teach the rules of the game and how to utilize them to succeed, earn, and progress (Gore Zeev, 1999). The themes of the present study and the teachers’ quotes illustrate the extent to which a collaborative learning environment centered around a project enables these conditions. Also, there is an added benefit of learning by doing projects as part of the learning process. During the group’s efforts to share and learn from each other, new ideas are offered, and a variety of possible solutions are offered, and these enrich learners’ repertoire of knowledge and responses (Murray & Ames, 1992). Other research findings also express these issues in various themes related to the teachers’ satisfaction with the process and the students’ initiatives. It can thus be seen that the collaborative learning environment is more dynamic (Metzler 2000), and is also necessarily organized differently (Tinzmann et al., 1990). It can change the entire school environment and the connection of students and teachers to the educational process.

In conclusion, this study shows that project-based collaborative learning has diverse implications in terms of its contribution to the school, as seen in its assessment by teachers and its ability to change the entire learning environment. Therefore, it is crucial to continue to develop similar projects in each learning environment, intending to ensure that these processes create opportunities for students to become more familiar with meaningful learning processes and to align their interests with the knowledge acquired in schools.

5. Recommendations for future research

Future research investigating the advantages of collaborative project-based learning environments should include the perspective of the teachers, parents, and students. Through the interviews with the teachers, this study strove to understand their experiences in the project. Future research may study the interactions during classes and other project-related events in order to describe what is happening in the collaborative learning group. Additionally, future research can test the differences between students of different ages that take part in the collaborative learning program, as well as gender differences that are relevant to those projects.

In conclusion, researchers can investigate whether a change of the test subjects and a focus on a different subject (not a STEM project) may affect the group’s conceptions, characteristics, and values through conducting research that compares different groups.

Reference

Barak, M., & Assal, M. (2018). Robotics and STEM learning: Students’ achievements in assignments according to the P3 Task Taxonomy—practice, problem solving, and projects. *International Journal of Technology and Design Education*, *28*(1), 121–144. https://doi.org/10.1007/s10798-016-9385-9

Bauer, M. W., & Gaskell, G. (2008). Social Representations Theory: A Progressive Research Programme for Social Psychology. *Journal for the Theory of Social Behaviour*, *38*(4), 335–353. https://doi.org/10.1111/j.1468-5914.2008.00374.x

BenEzer, G. (2012). From Winnicott’s potential space to mutual creative space: A principle for intercultural psychotherapy. *Transcultural Psychiatry*, *49*(2), 323–339. https://doi.org/10.1177/1363461511435803

Booker, M. J. (2007). A Roof without Walls: Benjamin Bloom’s Taxonomy and the Misdirection of American Education. *Academic Questions*, *20*(4), 347–355. https://doi.org/10.1007/s12129-007-9031-9

Council, N. R., Education, D. of B. and S. S. and, Sciences, B. on B., Cognitive, and Sensory, & Practice, C. on D. in the S. of L. with additional material from the C. on L. R. and E. (2000). *How People Learn: Brain, Mind, Experience, and School: Expanded Edition*. National Academies Press.

Crismond, D. P. (2011). Scaffolding Strategies For Integrating Engineering Design and Scientific Inquiry in Project-Based Learning Environments. In M. Barak & M. Hacker (Eds.), *Fostering Human Development Through Engineering and Technology Education* (pp. 235–255). https://doi.org/10.1007/978-94-6091-549-9\_13

Dakers, J. R. (2011). Activity Theory as a Pedagogical Framework for the Delivery of Technology Education. In *Fostering Human Development Through Engineering and Technology Education* (pp. 19–34). https://doi.org/10.1007/978-94-6091-549-9\_2

Dewey, J. (1938): Experience and education. *The later works of John Dewey* (Vol. 13). Carbondale: Southern Illinois University Press, 1-62.

Dolmans, D. H. J. M., Grave, W. D., Wolfhagen, I. H. A. P., & Vleuten, C. P. M. V. D. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education*, *39*(7), 732–741. https://doi.org/10.1111/j.1365-2929.2005.02205.x

Fransella, F. (Ed.). (1982). *Psychology for occupational therapists: [Edited by] Fay Fransella*. London: Macmillan.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99–107. https://doi.org/10.1080/00461520701263368

Holm, M. (n.d.). *PROJECT-BASED INSTRUCTION:* 13.

Hushman, C. J., & Marley, S. C. (2015). Guided Instruction Improves Elementary Student Learning and Self-Efficacy in Science. *The Journal of Educational Research*, *108*(5), 371–381. https://doi.org/10.1080/00220671.2014.899958

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, *41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102\_1

Kolmos, A. (1996). Reflections on Project Work and Problem-based Learning. *European Journal of Engineering Educatio*, *21*(2), 141–148.

Ramaekers, S. (2010). Multicultural education: Embeddedness, voice and change. *Ethics and Education*, *5*(1), 55–66. https://doi.org/10.1080/17449641003665951

Rose, S., Habgood, J., & Jay, T. (2017). An exploration of the role of visual programming tools in the development of young children’s computational thinking. *Electronic Journal of E-Learning*, *15*, 297–309. Retrieved from http://www.ejel.org/volume15/issue4/p297

Savery, J. R. (2006). Overview of problem-based learning: Definition and distinctions, The interdisciplinary. *Journal of Problem-Based Learning*, 9–20.

Tal, T., Krajcik, J. S., & Blumenfeld, P. C. (2006). Urban schools’ teachers enacting project-based science. *Journal of Research in Science Teaching*, *43*(7), 722–745. https://doi.org/10.1002/tea.20102

Thomas, J. W. (n.d.). *A REVIEW OF RESEARCH ON PROJECT-BASED LEARNING*. 46.

Tsybulsky, D., & Muchnik-Rozanov, Y. (2019). The development of student-teachers’ professional identity while team-teaching science classes using a project-based learning approach: A multi-level analysis. *Teaching and Teacher Education*, *79*, 48–59. https://doi.org/10.1016/j.tate.2018.12.006

Vonk, J. H. C. (1995). *Conceptualizing Novice Teachers’ Professional Development: A Base for Supervisory Interventions*. Retrieved from https://eric.ed.gov/?id=ED390838

Zadok, Y., & Voloch, N. (2018). Applying PBL to teaching robotics. *International Journal of Innovation and Learning*, *24*(2), 138–151. https://doi.org/10.1504/IJIL.2018.094068