Croatian Journal of Education
Vol.23; No.3/2021, pages: 731-765
Original research paper
Paper submitted: 4th February 2019
Paper accepted: 12th June 2021
https://doi.org/10.15516/cje.v23i3.3570

The Comparison of Problem Based and Project Based Learning Methods in Physics Teaching

Sabri Kan[1] and Ahmet Zeki Saka[2]
[1]Ataturk Science and Art Centre
[2]Faculty of Education, Trabzon University

Abstract

The aim of this study is to compare the Project Based Learning (PjBL) and Problem Based Learning (PBL) applications used in physics teaching according to the students' academic achievement development, Problem Solving Skills (PSS) development and analysis of application environments. This research was carried out based on the specific situation method with 48 students studying in the 9th grade in which "Electricity and Magnetism" unit in physics class is taught at a Science High School located in the Marmara Region of Turkey. Quantitative and qualitative data collection tools were used in the study. Quantitative data were analyzed with the use of the SPSS statistical program. Qualitative data were evaluated by using content analysis and document analysis. The findings suggest that the applications based on the PBL method are more effective than the applications based on the PBL method. In addition, both methods contribute to increasing students' academic success, their interest in physics and their responsibilities towards learning physics. According to the results of the research, physics teachers should obtain relevant information necessary for forming compatible groups when applying the PBL and PBL methods in the classroom.

Key words: *physics teaching; project based learning; problem based learning; problem solving skills; electricity and magnetism.*

Introduction

The suitable development and application of teaching programs according to age requirements contributes to the modernization of the teaching process. With the physics-teaching program prepared by the Ministry of Education, a proper transition between primary and secondary teaching is granted.

The key concepts within the teaching program of life sciences create an important basis for the preliminary knowledge of students required in the physics course. In addition to the spiral approach in the study, gains within the scope of Scientific Process Skills, Science-Technology-Society-Environment, and Attitude and Values have created important reflections for the new physics-teaching program (Ministry of National Education, 2007). It can be stated that the physics-teaching program focuses on a two directional target in the dimension of knowledge and skills gains.

Research shows that incorrect teaching methods used in physics teaching have an important role to understanding the physics course (Elby, 1999; Ayvacı & Bebek, 2018; Inac & Tuksal, 2019). In recent years, Project Based Learning (PjBL), in which students are exposed to daily-life problems and required to develop solutions using Problem Based Learning (PBL), has started to find a place in teaching programs more often (Blumenfeld et al., 1991; Diggs, 1999; Duch, et al., 2001; Korkmaz, 2002; Şahin, 2009; Demirel & Arslan Turan, 2010). The Project Based Learning method is a teaching method which aims at the solution of problems by individual or small groups of students. In other words, it puts in the center a learner's transformation from a passive receiver to a creative individual who researches, examines, accesses knowledge, solves problems with the acquired knowledge, and thinks independently in the learning-teaching process (Schmidt & Fisher, 1992). One of the important advantages of this method is that it provides the awareness of responsibility in individuals taking on group duties (Moursund, 2003). According to information obtained from various studies (Bilen 2002; Erdem, 2002; Korkmaz, 2002; Yaman, 2005; Boyle & Rigg, 2006; İçelli et al., 2007; Kılınç, 2007; Sert Çıbık & Emrahoğlu, 2008, acc. to Tuncer, 2009; Grant, 2002; Tuncer, 2009; Noordin et al., 2011; Kan, 2013; Uysal 2016;), it is possible to compare PjBL and PBL methods in Table 1 in terms of their similarities and differences.

The studies done point out that the first examples of the Project Based Learning Method can be found in the works of Protagoras and Aristoteles. Howard Borrows carried at the Medicine Faculty of McMaster University out the first serious application in 1976 in Canada. The application was later accepted in the scope of undergraduate and graduate programs at many universities, such as American School of Medicine in 1970, Roskilde in 1972, Aalborg University in 1974, and Olin College in 1997 (Korkmaz, 2019; de Graaff & Kolmos, 2007). In today's educational systems, the Project Based Method has a wide area of application in various teaching programs, especially in primary and secondary education and in medicine, engineering, language education, architecture, and law (Howell, 2003; Coşkun, 2004).

In 2008 and 2013, important changes were made in Turkey in the physics education program, which had not undergone changes for a long time. These changes brought about new responsibilities for the teachers such as applying new learning and teaching methods and deciding which of these methods would really ensure effective implementation of the course. The existence of many abstract concepts in the physics course caused these new responsibilities to become even more important for physics teachers. In the literature, there are numerous studies indicating that Project Based Learning and Problem Based Learning methods are effective in teaching abstract concepts (Harland, 2002; Harris et al., 2001; Mayer, 2002; Seloni, 2005). However, more studies should be done in this field due to insufficient examples of the PjBL and PBL application in physics teaching and the lack of sample applications based on PjBL and PBL.

Table 1
Similarities and differences between PjBL and PBL methods

Similarities	Differences
Solutions for a problem from daily life are sought.	While it is expected for PjBL to result with a product, in PBL, abstract solutions are also expected.
Teachers are not only sources of information but also guides.	Although PjBL is not suitable for young students at the primary school level, PBL can also be applied in a younger student group.
Multiple solutions are sought for problems or events.	While it is possible to test the created model or product in PjBL, there is no obligation to try the presented solutions to the problems in PBL.
Students are actively involved in the learning process.	According to the PBL, the need for equipment and stationery is greater in the implementation of the PjBL.
It is based on cooperation and group work.	In PBL, the application steps can be relocated, but the PjBL steps must be followed in sequence.
The group is assessed based on individual evaluation and performance by rubrics.	Even though PjBL is appropriate for interdisciplinary studies, PBL is more based on a single discipline.
It requires longer practice than other learning methods.	Both methods are different from each other in terms of problem qualities.
It enables students to use basic skills, such as logical thinking and making ideas, hand, muscle and coordination, as well as other basic skills.	Although the PjBL is more focused on single problems, more than one problem can be dealt with in PBL.

The basis of the *Electricity and Magnetism* unit starts in primary education. In many studies done about this unit, it is emphasized that students define the related concepts as difficult and complex (Asomi et al., 2000; Cohen et al., 1982; Çıldır & Şen, 2006; Duit & Rhöneck, 2007; Frederiksen et al., 1999; Heller & Finley, 1992; Küçüközer, 2003; Örgün, 2002; Pardhon & Bano, 2001; Psillos et al., 1988; Sencar & Eryılmaz, 2002; Shipstone et al., 1988; Sönmez et al., 2001). The concepts of electricity such as the current, voltage, potential difference, resistance, etc. constitute a comprehensive dimension of the physics course. For this reason, it is expected of the study to provide a contribution towards filling the gap in this area. On the other hand, the absence of studies in Turkey on comparing the implementation of PjBL and PBL methods further increases the importance of the carried-out work.

In recent years, and with increasing popularity, the implementation of Project Based Learning and Problem Based Learning in the Turkish educational system has found its place among the effective teaching methods, with the potential of acquiring the gains targeted by the physic-teaching program (Yavuz & Yavuz, 2017). Although meta-analysis studies of these methods are available (Üstün, 2012), comparative studies on the effects of use of PjBL and PBL in physics teaching are not often found in literature. It is presumed that comparative studies done in this research will contribute to evaluating the implementation of these two methods in order to develop quality materials for the physics course. It is expected that the results obtained from this study will provide clues to physics teachers as to which method is generally more effective for use in the physics course, and specifically in the scope of the electricity unit. Therefore, the aim of this research was to compare the practices of PjBL and PBL in physics teaching. According to the research aim, we set the following research questions:

1 Which of the two methods, PjBL or PBL, has a greater effect of students' academic achievement in physics?
2 Which of the two methods, PjBL or PBL, has a greater effect on students' problem-solving skills (PSS) development?
3 Considering the analysis of application environments such as classrooms and laboratories, which of the methods, PjBL or PBL, is more practical and useful for teaching physics?

Method

In this research, qualitative and quantitative data collection methods were used together, based on the mixed method model in social sciences. The effects of each independent variable, i.e. PjBL and PBL, on the development of group members' PSS was examined with pretests and post-tests. Quantitative data were obtained by using a semi-experimental study type. Experimental studies are defined as research designs that are used to explore cause-and-effect relationships between variables (Büyüköztürk, 2007). Semi-experimental studies are carried out in a similar way. However, in semi-experimental studies, it is necessary to form the groups according to some selective variable, rather than by chance (Ekiz, 2003; Karasar, 2006). In this study, during the formation of the groups for PjBL and PBL's implementation, attention was paid to selecting high school students with homogenous characteristics, according to their placement scores

Researchers give importance to the realization of short-term implementation in order to measure the effect of the independent variable in such studies (Cohen & Manion, 1994; Nachmias & Nachmias, 1997; Karasar, 2006; Mısır, 2009).

The qualitative data of the study were gathered through observations done in the application process, analysis of the teaching material, informal interviews, and the face-to-face interview done at the end of the study.

Study group

This study was conducted with 48 students from the ninth grade of Science High School in the Marmara Region during the spring semester of the 2010-2011 academic year. One of the two classes from the sample with 24 students was based on PjBL and the other on PBL method. In order to evaluate the equivalence of the two groups included in the study, two types of data were used: physics course grade averages of the first semester of the academic year when the study was implemented, and the results of high school placement test. According to the results of the independent t-test, it was determined that no significant difference exists between the students' physics grades and high school placement grades (p>.05), and that these two classes consist of equivalent groups.

The results of the independent t-test for students' physics grades, their demographic characteristics, number of participants in the groups, and the applied teaching method are presented in Table 2.

Table 2
Results of the t-test applied to groups in the sample

Application Carried Out	Class and Section	Number of Students (N=48)		Comparison of the physics exams of the groups		
		Male	Female	$\overline{X}$	t	p
PjBL	9-A	10	14	69.81	1.326	.517
PBL	9-B	10	14	67.08		

Data gathering tools

The necessary permits were obtained from the Provincial Directorate of National Education for all data collection tools used in the research. Brief descriptions of the data collection instruments used in the research are provided below.

Problem Solving Inventory (PSI): This questionnaire was developed by Heppner and Peterson (1982), and it was used in this research as a pretest and post-test. The questionnaire's original name is Problem Solving Inventory, Form-A (PSI-A), and it has been adapted to Turkish by Şahin et al. (1993). The scale with 35 items is in the form of a six-point Likert Scale. Out of the 32 items included in the evaluation, 16 indicate positive and 16 negative judgments. Three items from the inventory that were not a part of the physics-teaching program were excluded from the evaluation.

Problems Solving Skills Test (PSST): This scale was developed by the researchers in order to determine the level of the 13 PSS in *Electricity and Magnetism* unit from the physics teaching program. Validity and reliability testing was conducted for this scale, which was developed through two pilot applications. For this purpose, two academics and eight teachers conducted content review, compatibility and parallel studies. Within the scope of the implemented pilot studies, the PSST consisting of open-ended questions was applied to a total of 108 students. Taking into consideration the data obtained from the pilot applications, questions that were difficult to understand were rearranged without changing the characteristics representing the relevant PSS. In this test, the students have answered questions about basic knowledge on electricity, brightness of lamps, resistance of conductors, potential difference, functions of circuit elements, Ohm's law, the conclusions on electrical experiments, current and potential difference calculations, and equivalent resistance.

The scale used as pretest and post-test consists of 10 open-ended questions. There is no factor threatening the validity of the structure in open-ended scales according to the Likert or multiple-choice scales (Güler, 2014). On the other hand, in such open-ended scales, where the right answer is not presented within the options, the actual skills of the students are determined more effectively. In this study, the determined reliability coefficient of the scale was .76. The scoring in the PSST was 2, 1, and 0 points for completely correct, partly correct and wrong answers, respectively. Accordingly, the highest possible score was 20 (10x2).

Physics Course Attitude Scale (PCAS): This scale is an adaptation of the Science Course Attitude Scale developed by Geban et al. (1994) with 15 questions. It was used as pretest and post-test in order to find out the students' interest in the physics course. The scale's reliability was calculated at .82, and it was in the form of a 5-point Likert Scale, with responses from "completely agree" to "completely disagree".

Face-to-face interview: Face-to-face interview was used in the research because of its features that provide the researcher with flexibility, allow the students to investigate their mistakes thoroughly, and create an opportunity to investigate an unusual situation that is in the foreground during the problem solving process. After the applications carried out in the scope of the study, semi-structured face-to-face interviews were done with five students purposefully selected to represent the groups who participated in the PjBL and PBL implementation. The interview included three fundamental questions about the gains of the application process and, at the same time, students' attitudes towards physics, and thoughts on the implementation.

PjBL and PBL Course Guide Material: Prior to the applications, each student in both groups was given a leaflet developed by the researcher. In devising the leaflet, steps of the PjBL method developed by Korkmaz (2002) and Moursund (2003) were taken into consideration, as well as the process of seven steps with three main stages. On the other hand, the PBL leaflet prepared within this study, as a synthesis of the application steps proposed by Wood (2003) and Jonhson (2003), consists of 23 pages in total. Taking into account the achievements of *Electricity and Magnetism* unit in the curriculum, the course guide materials prepared according to the new PjBL and PBL application steps determined below were firstly tested through a pilot study, and so the identified problems were resolved and final shape given to the material.

Observation: Informal observations aimed at determining students' behavioral responses in the learning environments in the study. The observations entailed students' responses about the applied teaching method and their attitudes towards the physics course, and the researcher noted them daily.

Application

This study was conducted for a total of 7 weeks. With permission from the Provincial Directorate of National Education, the researcher introduced the methods of PjBL and PBL and carried out the pretest and formed in-class study groups. In the scope of *Electricity and Magnetism* unit, physics activities were implemented in the selected classes twice a week, in the course of 5 weeks. In the last week, post-tests were applied and face-to-face interview and evaluations were done. The researcher implemented all activities in the class process, whereas subject teachers participated as observers.

The implementation of PjBL

In the present study, the implementation of PjBL in the learning environments were analyzed in three main stages: introduction, preparation and research, and presentation and discussion. Only the teachers were active in the first stage, the students in the second, and teachers and students both in the third. PjBL was primarily introduced to the students who participated in the model's implementation.

The class in which the model was implemented was divided into 5 groups. One subject within *Electricity and Magnetism* unit was assigned as a project task to each group in the form of a document, which provided information on the project steps and delivery deadlines. The PjBL implementation method is presented in Table 3.

Table 3
The PjBL implementation steps used in the study

	Stages	Setting for the task implementation	Tasks to be done	Teacher's role	Student's role
Introduction Stage	1. Determining project subjects	Classroom setting	The determination of the project subjects according to the teaching program of the course.	Presents the general subject of the investigation. Determines sub-topics of the general subject. Guides a group during discussions.	Creates interesting problems related to the projects. Categorizes the questions, contributes to the formation of project groups.
	2. Determining the team and work schedule	Classroom setting	Members of the group making the project plan together. Deciding about questions like where, how and when to go, and sharing the work.	Helps groups to formulate the projects, talks with the groups. Reminds them of the presentation dates.	Plans what to work on, chooses resources, defines roles, and provides the delivery of the plans.

	Stages	Setting for the task implementation	Tasks to be done	Teacher's role	Student's role
Preparation and Research Stage	3. Synthesis of information	Home library, reading room, etc., indoor and outdoor spaces	Execution of individual or joint tasks by the group members. Analysis of data by the students.	Helps make available the necessary material and resources. Helps to develop research and study skills, control the basic process and the groups.	Selects resources, identifies roles, ensures delivery of the plans, seeks answers to questions, collects data, organizes the information, talks with resource persons. combines and summarizes the findings
	4. Preparing models or presentations	Home library, reading room, etc., indoor and outdoor spaces	Preparation of appropriate models for the project. Identification of the key points in the presentation by the members and deciding on the manner of presentation for the findings.	Controls the presentation. Supervises the compliance of the model or presentations with the course content.	Determines the plan, the content and form of the presentation. Ensures the preparation (computer, posters, flyers, etc.) for the presentation.
Presentation and Discussion Stage	5. Promotion	Learning environments such as classroom and laboratory	The implementation of the promotion of presentations or the Project models in learning environments.	Organizes the presentations.	Presents the projects in teams or through group representatives.
	6. Discussion	Learning environments such as classroom and laboratory	The questioning of projects or presentations by other groups.	Evaluates the projects and the student groups.	Reflects on the study and what is learnt as group members.
	7. Evaluation	Learning environments such as classroom and laboratory	Determination of whether the planned outcomes in the teaching program have been achieved or not.	Ensures awareness of the outcomes of the teaching program.	Questions whether the respective outcomes have been achieved or not.

The implementation of PBL

In the general sense, PBL is a learning method which could be applied based on cooperation. In this study, pilot applications were done in order to test the correspondence of theory, information and activities of implementation. In the pilot and main implementation classes, an eight-step application method was developed based on Wood (2003) and Johnson's (2003) application steps. Similar to the PjBL implementation, students were introduced to the method before the work itself. At the end of the presentation, learning groups were formed by dividing students into 5 teams, after which the other seven steps were implemented. The developed PBL steps and the carried out activities are presented in Table 4.

Table 4
The application steps of the PBL method used in the research

Steps	Tasks to be carried out	Teacher's role	Learner's role
1. Determining teams and goals	Formation of study groups. Determination the goals of the subject's teaching program.	Presents the general subject of the research and the outcomes to be achieved in the process.	Follows the teacher carefully, defines the targeted knowledge.
2. Explaining problem scenarios	Giving the problem scenario to the students and reading it in the learning environment.	Provides the explanations related to the problem scenario. Explains the relationship between the problem scenario and the learning goals.	Tries to understand the scenario. Asks questions about unclear points in the scenario.
3. Analyzing scenarios	The groups discuss problem scenarios within themselves. Task allocation is done in order to answer the questions in the scope of the scenarios.	Answers the questions of the groups regarding the problem scenarios. Controls the basic process and the groups.	Tries to understand the problem completely. Fulfills his own responsibility within the group.
4. Supplying missing knowledge	Researching basic information about the given problem.	Helps finding necessary materials and resources. Contributes to the development of research and study skills.	Researches the answers to the questions asked. Collects data.
5. Synthesizing information	Determining the compliance of the collected data with the subject in the problem scenario.	Follows the process, provides the correct guidance in the synthesis of information.	Organizes knowledge. Combines and summarizes findings.
6. Presenting suggestions for solutions	Determining suggestions for the solution of the problem. Evaluation of the solutions between the groups. Formation of common solutions. Exposing general knowledge about the subject in the teaching process.	Makes possible for the groups to answer the questions in the given problem scenario and shapes the common solution. Reveals general knowledge from the student solutions in the scope of the teaching program.	Shares group solutions and evaluates solutions by other groups.

Steps	Tasks to be carried out	Teacher's role	Learner's role
7. Determining similar situations	Creating similar problems related to the same learning areas. Adapting information on the subject in the teaching process to other environments.	Ensures the use of relations between issues and concepts within the context of the teaching program in other inquiries by the students.	Makes connections by identifying other possible problems within the scope of the learnt subject.
8. Evaluation	Determining whether the teaching program's outcomes are achieved.	Provides awareness of the achievements within the teaching program.	Inquiries about the adequate achievement of the respective gains.

As seen in Table 4, all the steps are aimed at designing the PBL method so it can be carried out in the classroom setting. By providing textbooks, computers and internet connection, the researcher overcame the problem of accessing sources of information, which was noticed not only in the related literature but also in the pilot study. Thus, the effect of this variable was reduced to a minimum.

Data collection and analysis

Within this research, PjBL and PBL applications in each class were recognized as independent variables, whereas students' problem-solving skills and academic achievements were recognized as dependent variables. The data collection instruments used in this study are described in more detailed below.

Analysis of PSI and PSST data: SPSS 22.00 statistical program was used in the analysis of PSI and PSST, which were used as pretest and posttest. Before deciding on which tests to use in analyzing the obtained data, their normality level was determined. The obtained normality levels were 0.668 for the pretest and 0.724 for the posttest. Due to parametric properties of the obtained data, a paired-samples t-test was used for within-groups comparisons, and independent t-test was used for intra-groups comparison (Akbulut, 2010).

According to the analyses, Wilk's lambda value was interpreted to determine the common effect, and .05 level of significance was adopted. In addition, the level of student PSS was studied in the content analysis of PSST.

Analysis of the PCAS data: The analysis for PCAS was limited to basic statistical findings.

*Analysis of face-to-face interview and observation*s: By converting the conducted face-to-face interviews into written form through decoding method, similar and different responses to each question were analyzed primarily by being organized into a table. The same or similar expressions in the table were converted into a single expression by correcting the spelling mistakes. The researcher recorded his observations for each lesson daily. The data obtained from these notes were compared with other data and taken into account in the in-depth analysis of the research.

While descriptive analysis was used in processing data that do not require in-depth analysis, content analysis entails closer examination of the obtained data and access to the concepts and themes describing them (Yıldırım & Şimşek, 2008). Face-to-face interviews conducted with six students from each group at the end of PjBL and PBL applications were coded so that similar expressions were classified. A relation network was created to determine which goals and PSS were entailed by these codes. Thus, it has ensured quantitative and qualitative comparison between the frequency and content of the statements reflecting the students' opinions obtained in the interview.

The analysis of student material in the application of the PjBL and PBL methods: The relevant areas for reflecting the students' PSS on the application material were examined by descriptive analysis, i.e. document analysis. As examples of these areas, the following can be stated: defining the problem based on understanding the project subject and the given scenario, determining variables by building a hypothesis, reaching generalizations from data, and testing the effect of the variables on the model.

Findings

The distribution's normality was confirmed in the analysis of the PSI, in which the levels of students' problem solving skills were evaluated with 32 items. The Cronbach's Alpha coefficient of the PSI was .86. The analysis was carried out by excluding three items (9, 22, 29) of the scale which did not measure PSS, and by reorganizing the items which reflected a negative judgment with reverse coding. Because the p value of the Box's M test examined in this analysis was not significant, the equality of covariance condition was met. In addition, it was determined that the correlation between variables among the groups were equal. Also, according to the homogeneity test of PSI and PSST scales, the variances were homogenous.

Table 5
Paired t-test analysis for PjBL-PBL implementation classes

Data gathering tools	Grup	N	Test	$\overline{X}$	Ss.	t	p
PSI	PjBL	24	Pretest	3.896	.212	8.011	.000
		24	Posttest	3.445	.173		
	PBL	24	Pretest	3.800	.243	6.193	.000
		24	Posttest	3.533	.177		
PSST	PjBL	24	Pretest	6.375	3.104	-10.575	.000
		24	Posttest	13.958	3.085		
	PBL	24	Pretest	7.083	2.535	-8.666	.000
		24	Posttest	11.791	3.216		

Table 5 shows that the implementation of PjBL and PBL has positive effects on the students' problem-solving skills ($P< .05$). On the other hand, as seen from the table, the obtained pretest average value for the students participating in the implementation of PjBL is 6,375, while the post-test average value is 13,958 for PSST.

Table 6
Independent sample t-test analysis for PjBL-PBL implementation classes.

Data gathering tools	Grup	N	Test	$\overline{X}$	Ss.	t	p
PSI	PjBL	24	Pretest	3.896	.212	1.442	.156
	PBL	24		3.800	.243		
	PjBL	24	Posttest	3.445	.173	-1.749	.087
	PBL	24		3.533	.177		
PSST	PjBL	24	Pretest	6.375	3.104	-.866	.306
	PBL	24		7.083	2.535		
	PjBL	24	Posttest	13.958	3.085	2.381	.021
	PBL	24		11.791	3.217		

As seen in Table 6, there is a significant difference between the PSST averages (p=.021 and p<.05).

As seen in Table 5 and Table 6, PSI test indicates no significant difference in the development of problem-solving skills of students participating in PjBL and PBL applications. According to the PSST data, problem solving skills of students who participated in PjBL have significantly improved, compared to those who participated in the implementation of PBL. No significant difference was found between the scores of the students participating in PjBL and PBL applications in the pretest of this scale.

Furthermore, it was determined that the posttest values of the participants are higher than their pretest values. On the other hand, except for questions 6 and 8, the skills development of students participating in PjBL implementation are at a higher level than among students participating in PBL implementation. Moreover, it was noted that a higher number of correct expressions reflecting PSS were used in 8 questions by students participating in PjBL application, whereas in only 2 questions by students participating in PBL application.

Data obtained from PCAS, in which students' thoughts and attitudes were determined, are presented in Table 7.

Table 7
PCAS t-test analysis

Scale	Grup	N	$\overline{X}$		Ss		t		p	
			Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
SCS*	PjBL	24	50.44	64.50	4.48	3.62	-1.12	1.08	.46	.01
	PBL	24	48.70	56.02	6.02	12.54				

*Science Course Scale

According to the findings presented in Table 7, the attitudes of students participating in PjBL applications have developed more in the positive direction. Descriptive statistics for the PSI and PSST posttests are presented in Table 8.

Table 8
Descriptive statistics related to PSI and PSST

Data gathering tools	Grup	N	Test	$\overline{X}$	Chang According to Pretest (%)	ss	Minimum	Maximum
PSI	PjBL	24	Pretest	119.21		9.32	114.00	165.00
	PBL	24		137.63		10.11	114.00	165.00
PSST	PjBL	24		9.30		1.04	5.00	20.00
	PBL	24		9.69		1.24	4.00	17.00
PSI	PjBL	24	Posttest	153.21	28.57	11.70	133.00	178.00
	PBL	24		156.71	13.86	11.94	133.00	174.00
PSST	PjBL	24		13.96	50.10	3.09	9.00	20.00
	PBL	24		11.79	21.67	3.22	3.00	17.00

As seen from Table 8, the PSST average values of the participants in the PjBL application have increased from 119,21 to 153,21. A similar increase was observed in the average scores of students who participated in PBL applications (from 137,63 to 156,71). However, it is seen that participants in PjBL implementation increased (%50,10) these skills more than those who participated in PBL (%21,67).

The face-to-face interviews carried out in the scope of the research were examined through descriptive and content analysis. As an example of this analysis, the relationship network of PSS3 is shown in App. 1. Table 9 presents the codes obtained from the relationship networks regarding PSS in the scope of *Electricity and Magnetism* unit, and the frequencies obtained from these codes.

As seen in Table 9, when the frequency values of the produced themes are compared, in the reflection of skills, except for PSS6, it was found that the students participating in PjBL applications have more correct expressions that the students participating in PjBL applications

Observation is another data-collection tool in this study. It was found that students participating in PjBL and PBL implementation generally do not reflect the expected gains in the first week of the implementation. When the data for the last week of the PjBL implementation are observed, it is visible that all but three gains are reflected in the students' learning environment. It was determined that the students in the group where the PBL method was applied have learned some problem-solving skills and behaviors included in the curriculum, but they have not fully learned some of these skills. This situation was noted in the learning environments.

The observations about the participants in the PjBL's implementation written daily by the researcher in the last week:

"The presentation prepared by the project group have been successfully implemented in the learning environment. Although problems arose during the working process of the model, it helped other groups gain important information about how an electric motor works. It was also observed that the other groups asked questions suitable to the model. In this week's application, it was observed that students perceive the concept of variable correctly, and that they use this concept correctly in their conversations."

Table 9
Comparison of interview expressions of students participating in PjBL and PBL implementation.

Themes in Electricity and Magnetism unit related with PSS	PSS number in the curriculum	Frequency of expressions related to the theme (f)	
		PjBL	PBL
Changing potential difference by keeping resistance constant Changing resistance by keeping potential difference constant Formula expressing current Choosing materials suitable for the problem and presenting suggestions for solution Hypothesis building and testing variables Correctly evaluating the problem solution and the result	PSS3	67	53
Choosing materials suitable for the problem and presenting suggestions for the solution Hypothesis building and testing variables	PSS4	26	19
Choosing materials suitable for the problem and presenting suggestions for solution Hypothesis building and testing variables	PSS5	26	19
Changing potential difference by keeping resistance constant Changing resistance by keeping potential difference constant Hypothesis building and testing variables	PSS6	29	29
Signifying physics concepts with their terms	PSS7	23	8
Formula expressing current	PSS10	9	4
Correctly evaluating the problem solution and the result	PSS11	16	14
Correctly evaluating the problem solution and the result	PSS13	16	14

Furthermore, the notes of the researcher about the last week of the PBL applications are presented below:

"It was observed that the student groups completely adapted to the applications. It was observed that the communication within and across groups was better. Another noticeable situation in this week's applications is that the groups use the application material completely and correctly, and that they successfully applied the PBL steps in the correct order."

In sum, it was determined that the students who participated in the PjBL implementation developed adaptive behavior towards this method in a shorter time, whereas the adaptation time for students who participated in the PBL application was longer.

General unity was found in the use of the PjBL and PBL application material developed for the study. In the first two steps of implementing these materials, students were not required to do any work.

Information research is part of the implementation material common in both methods, wherein students are required to carry out research on the learning objectives. It was determined that the students completed this part of PjBL and PBL properly. According to their statements, students have completed specific sections of the training material properly. Participants in the PjBL implementation gave more detailed explanations than students who participated in the PBL application. Similarly, participants in the PjBL application completed this section of the material more carefully than students who participated the PBL applications.

In conclusion, it was determined that students participating in the PjBL and PBL application completed the materials in line with the objectives of the applied teaching methods and goals. However, it was found that the students participating in the PjBL application behaved more attentively during the material's completion.

Discussion, result and implications

This research sought to compare the implementation of PjBL and PBL in physics teaching. It is stated in the literature that PjBL and PBL's implementation contributes to teacher-student and student-student interaction and improves teamwork skills (Lee & Tsai, 2004). These interactions also came to the foreground in the present study. In the implementation, it was observed that the PBL method helps students foresee what they are to do in the lesson process, and it encourages planned study in learning environments. It was noticed that the PjBL application provides opportunities for students to produce original work, especially in tasks with final products, and that it provides opportunities for presenting their individual skills, such as handicrafts. However, it is remarkable that in the implementation of PBL, oral solutions come to the forefront more.

The evaluation of the research findings showed that the PjBL application has a more positive effect on the students' PSS development, compared to the PBL's implementation. On the other hand, it was proven that students participating in the PjBL application used more correct statements, compared to those participating in the PBL application, which is an indication that the PjBL implementation has a more effective role in the development of PSS.

Another piece of data supporting this finding is that the frequency of incorrect statements used by students participating in the PBL application is higher. The qualitative findings obtained from PCAS, which is another qualitative data source, also indicate that the PjBL application has a more positive effect on the students' attitudes towards the physics course, compared to PBL applications.

The other two research questions regard comparing the effects of PjBL and PBL application on the levels of students' PSS and academic achievement in physics. Statistical findings in this research have shown that both methods offer a positive contribution to understanding physics. Both methods were proven to contribute to students' greater interest in physics and to the development of academic success.

During face-to-face interviews conducted for this purpose, the created associative networks showed that the students participating in the PjBL applications were more successful in reflecting such skills. However, the students participated actively in both implementation processes. As understood from the reserach observations, the students willingly carried out these applications. In this respect, the literature highlights the contribution of PjBL and PBL implementation to increasing students' learning motivation (Saracaloğlu et al., 2006; Gültekin, 2007; Hatısaru & Küçükturan, 2009), which is corroborated by the results of the present study. On the other hand, the findings of Kaptan and Korkmaz (2002) and Gürlen (2011) show that both methods have a higher positive effect on the development of problem-solving skills than traditional methods. However, the absence of research on which of these methods is more effective in the development of the mentioned skills makes the results of the present research valuable.

The results of this research show that both the PjBL and PBL method have a positive effect on students' development of PSS. However, it could be stated that compared to the PBL method, the PjBL method has a greater effect on the development of these skills. This result is more evident when observing the qualitative scales. Students who participated in the PjBL implementation improved their problem-solving skills by 50%, while those who participated in the PBL implementation improved these skills by 21%. The same result is valid for students' achievement in physics.

When the findings obtained from the present study are considered more generally, it is visible that the students who presented a project, which they prepared in the course of the PjBL implementation in the classroom environment, are more successful in using their vocabulary, body language and listening skills. This contribution of PjBL creates a more lasting effect on learning the subjects weighted with abstract concepts, such as physics (Cengizhan, 2007; Ada et al., 2009). Moreover, the results of this research showed that the PBL application contributed significantly to students' communication skills. Among the characteristic features of PBL are presenting suggestions as possible solutions to defined problems, discussing these solutions in a group, and comparing the solutions with suggestions from other groups (Torp & Sage, 2002). In this respect, opportunities were created for students to incorporate their communication skills in their studies, through the implementation of PBL.

It is also thought that the competition that emerged between the groups in presenting problem solutions had a positive effect on acquiring more permanent knowledge, as well as that it effected the overall learning process positively.

The third problem of this research concerns which of the methods, PjBL or PBL, is more practical and useful in physics teaching, in comparison to traditional methods. The results showed that both methods attracted students' attention more than traditional methods. However, students complained about the lack of time in the implementation of PjBL.

During the process, some problems caused by communication between students made it difficult to implement PjBL. Despite this, it was found that students participating in PjBL application were trying to present the model, and they were more active in classes than their peers who participated in PBL. In this sense, it is believed that PjBL has a positive contribution to and provides motivation in physics class.

Based on the research results, general suggestions are given, and for the third problem, particular:

Prior to implementing the PjBL and PBL methods, teachers should inform the students in detail about these methods in order to increase their impact.

Implementation of PjBL and PBL is difficult when considering classroom preparation and control, in comparison to traditional methods. For this reason, teachers need to make serious preliminary preparations before classes. They should organize the laboratory and learning environments according to the implementation steps beforehand.

Teachers who are considering implementing practices based on PjBL and PBL methods should create groups that can work in harmony, taking into account the negative situations that might occur between students.

It has been determined that some problem scenarios used in the pilot practice and project topics do not attract students' attention, and the problem exists in implementing both methods. Therefore, problem scenarios and project topics for the implementation of PjBL and PBL should entice the students.

References

Ada, S., Baysal, N., & Kadıoğlu, H., (2009). Projeye Dayalı Öğrenme Yaklaşımı'nın Öğrencilerin Sosyal Bilgiler Dersine İlişkin Tutumlarına ve Görsel Sunu Uygulamalarına Etkisi [The effect of project-based learning approach on student's attitude of social studies and visual presentation practices]. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 10 (3), 89-96.*

Akbulut, Y. (2010). *Sosyal bilimlerde SPSS uygulamaları [SPSS applications in social sciences]*. İdeal Kültür Yayıncılık.

Asomi, N., King, J., & Monk, M. (2000). Tuition and memory: Mental models and cognitive processing in Japanese children's work on D.C. electrical circuits. *Research in Science and Technological Education,* 18 (2), 141-155. https://doi.org/10.1080/713694979

Ayvacı, H. Ş., & Bebek, G., (2018). A study on evaluation of the problems faced with teaching physics. *Kastamonu Education Journal*, 26 (1).

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating Project-Based Learning: Sustaining the doing, supporting the learning. *Educational Psychologist,* 26 (3 & 4), 369-398. https://doi.org/10.1207/s15326985ep2603&4_8

Boyle, G. A., & Rigg, R. (2006). *Technology Problem-Based Learning: The virtual benefits of the processes of critical thinking.* http://www.acadiau.ca

Bilen, M. (2002). *Plandan Uygulamaya Öğretim [Teaching: From plan to implementation]*. Anı Yayıncılık.

Cengizhan, S. (2007). Proje Temelli ve Bilgisayar Destekli Öğretim Tasarımlarının; Bağımlı, Bağımsız ve İşbirlikli Öğrenme Stillerine Sahip Öğrencilerin Akademik Başarılarına ve Öğrenme Kalıcılığına Etkisi [The effects of project-based and computer-assisted instructional designs on the students with depended, independed and cooperative learning styles, academic achievement and learning retention]. *Türk Egitim Bilimleri Dergisi,* 5 (3), 377-403.

Cohen, R., Eylon, B., & Ganiel, U. (1982). Potential difference and current in simple electric circuits: A study of students' concept. *American Journal of Physics,* 51(5), 407-412. https://doi.org/10.1119/1.13226

Cohen, L., & Manion L. (1994). *Research methods in educatio*n. Routledge.

Coşkun, M. (2004). Coğrafya Öğretiminde Proje Yaklaşımı [Project approach in geography teaching]. *Gazi Üniversitesi Kırşehir Eğitim Fakültesi Dergisi,* 5(2), 99-107.

Çıldır, I., & Şen, A. İ. (2006). Lise Öğrencilerinin Elektrik Akımı Konusundaki Kavram Yanılgılarının Kavram Harita Alanlarıyla Belirlenmesi [Identification of high school students' misconception about electric current by concept maps]. *Hacettepe Üniversitesi. Eğitim Fakültesi Dergisi*, 30 (30), 92-101.

de Graaff, E., & Kolmos, A. (2007). History of problem-based and project-based learning. In E. De Graaff & A. Kolmos (Eds.), *Management of change: Implementation of problem-based and project-based learning in engineering, 1-8.* https://doi.org/10.1163/9789087900922_002

Demirel M., & Arslan Turan B. (2010). The effects of problem based learning on achievement, attitude, metacognitive awareness and motivation. *H.U. Journal of Education*, 38, 55-66.

Diggs, L. L. (1999). *Student attitude towards and achievement in science in a problem-based learning educational experience*. Dissertation Abstract International, 59 (08), 2912A. (UMI No. 9842589)

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). *Why problem-based learning? A case study of institutional change in undergraduate education*. In B.J. Duch, S.E. Groh, & D.E. Allen (Eds.), *The power of problem-based learning* (pp. 3-11). Stylus Publishing.

Duit, R., & Rhöneck, C. (2007). Learning and understanding key concepts of electricity. httpllwww.physics.ohio-state.edu/jossemlICPElC2MC.htlm

Ekiz, D. (2003). *Eğitimde Araştırma Yöntem ve Metotlarına Giriş: Nitel, Nicel ve Eleştirel Kuram Metodolojileri [Introduction to research methods in education: Qualitative, quantitative and critical theory methodologies]* (1. Baskı). Anı Yayıncılık.

Elby, A. (1999). Another reason that physics students learn by rote, Physics education research, *American Journal of Physics Supplement,* 67(7), 52-57. https://doi.org/10.1119/1.19081

Erdem, M. (2002). Proje Tabanlı Öğrenme [Project based learning]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi* 22, 172-179.

Field, A. (2009). *Discovering statics using SPSS.* SAGE Publications.

Frederiksen, J.R., White B.Y., & Gutwill, J. (1999). Dynamic mental model in learning science: The impotance of constructing derivational linkages among models. *Journal of Research in Science Teaching,* 36 (7), 806-836. https://doi.org/10.1002/(SICI)1098-2736(199909)36:7%3C806::AID-TEA5%3E3.0.CO;2-2

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A., & Şahbaz, F. (1994). *Bilgisayar destekli eğitimin öğrencilerin fen başarılarına ve fen bilgisi ilgilerine etkisi [The effect of computer assisted education on students' science achievement and science interests].* Dokuz Eylül Üniversitesi, I. Ulusal Fen Bilimleri Eğitimi Sempozyumu Bildiri Özetleri Kitabı.

Güler, N. (2014). Analysis of open-ended statistics questions with many facet Rasch model. *Eurasian Journal of Educational Research*, 55, 73-90. https://doi.org/10.14689/ejer.2014.55.5

Gültekin, M. (2007). Proje Tabanlı Öğrenmenin Beşinci Sınıf Fen Bilgisi Dersinde Öğrenme Ürünlerine Etkisi [The effect of project based learning on learning outcomes in the fifth-grade science education]. *Elementary Education Online,* 6(1), 93-112. ilkogretim-online.org.tr/vol6say1/v6s1m8.pdf

Gürlen, E. (2011). The effect of problem based learning on learning outcomes, problem solving skills and self-efficacy belief. *Hacettepe University Journal of Education,* 40, 221-232.

Harland, T. (2002). Zoology studends' experiences of collaborative inquiry in problem based learning, *Teaching in Higher Education*, 7(1), 3-15. https://doi.org/10.1080/13562510120100355

Harris, K., Marcus, R., McLaren, K., & Fey, J. (2001). Curriculum materials supporting problem-based teaching. *School Science* & *Mathematics***,** 101(6), 310-318. https://doi.org/10.1111/j.1949-8594.2001.tb17962.x

Hatısaru, V., & Küçükturan, A. G., (2009). Student views on problem-based learning of 9th grade Industrial Vocational High School. *Procedia Social and Behavioral Sciences*, 1, 718-722. https://doi.org/10.1016/j.sbspro.2009.01.126

Heller, P. M., & Finley, F.N. (1992). Variable uses of alternative conceptions: A case study in current electricity. *Journal of Research* in *Science Teaching,* 29(3), 259-275. https://doi.org/10.1002/tea.3660290306

Heppner, P. P., & Peterson, C.H. (1982). The development and implications of a personal problem solving inventory. *Journal of Counseling Psychology*, 29, 66-75. https://doi.org/10.1037/0022-0167.29.1.66

İnaç, H., & Tuksal, H. R. (2019). Ortaöğretim Kurumları Fizik Eğitiminde Öğrenme Güçlüklerinin Belirlenmesi [Determination of learning difficulties in physics education in secondary education institutions]. *Mehmet Akif Ersoy Üniversitesi Uygulamalı Bilimler Dergisi*. 3 (1), 102-121. DOI:10.31200/makuubd.500460

İçelli, O., Polat, R., & Sülün, A. (2007). *Fen Bilgisi Laboratuvar Uygulamalarında Yaratıcı Proje Desenleri [Creative Project Patterns in Science Laboratory Applications]*. Maya Akademi.

Johnson, D. W. (2003). Social interdependence: The interrelationships among theory, research, and practice. *American Psychologist,* 58 (11), 931-945. https://doi.org/10.1037/0003-066X.58.11.934

Howell, R. T. (2003). The importence of the project method in technology education. *Journal of Industrial Teacher Education*, 40, 3.

Kan S., (2013). *Fizik Öğretiminde Proje Tabanlı Öğrenme ve Probleme Dayalı Öğrenme Uygulamalarının Değerlendirilmesi [Evaluation of project-based learning and problem-based learning applications in physics teaching], Unpublished Doctoral Thesis.* Karadeniz Teknik Üniversitesi, Trabzon.

Kaptan, F., & Korkmaz, H. (2001). Fen Eğitiminde Probleme Dayalı Öğrenme Yaklaşımı [Problem-based learning approach in science education], *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 20*, 191-192.

Karasar, N. (2006*). Bilimsel Araştırma Yöntemi [Scientific Research Method]*. Nobel Yayın Dağıtım.

Kılınç, A., (2007). Probleme Dayalı Öğrenme [Problem-based learning]. *Kastamonu Eğitim Dergisi*, 15(2), 561-578.

Korkmaz, H. (2002). *Fen Eğitiminde Proje Tabanlı Öğrenmenin Yaratıcı Düşünme, Problem Çözme ve Akademik Risk Alma Düzeylerine Etkisi [The effect of project-based learning on creative thinking, problem solving and academic risk-taking levels in science education].* Unpublished Doctoral Thesis. Hacettepe Üniversitesi, Ankara.

Kormaz, G., (2019). *Yükseköğretimde Proje Tabanlı Eğitim Programlarının İncelenmesi: Türk Üniversiteleri İçin Kavramsal Bir Model Önerisi* [The analysis of project based curricula in higher education: A conceptual model proposal for Turkish universities]. Unpublished Doctoral Thesis. Gazi Üniversitesi, Ankara.

Küçüközer, H. (2003). Lise 1 Öğrencilerinin Basit Elektrik Devreleri Konusuyla İlgili Kavram Yanılgıları [Misconceptions of first-year secondary school students about simple electric circuits]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi,* 25, 142-148.

Lee, C. I., & Tsai, F. Y. (2004) Internet project-based learning environment: The effects of thinking styles on learning transfer. *Journal of Computer Assisted Learning*, 20, 31-39. https://doi.org/10.1111/j.1365-2729.2004.00063.x

Mayer, R.E. (2002). Invited reaction: Cultivating problem-solving skills through problem based approaches to professional development. *Human Resource Development Quarterly*, 13, 3, 263-269. https://doi.org/10.1002/hrdq.1030

MNE (MEB), (2007). *Ortaöğretim Fizik Dersi Öğretim Programı [High school physics course curriculum]*. MEB Yayınlar Dairesi.

Mısır, N. (2009). *Elektrostatik ve Elektrik Akımı Ünitelerinde TGA Yöntemine Dayalı Olarak Geliştirilen Etkinliklerin Uygulanması ve Etkililiğinin İncelenmesi [The application of the activities developed on the basis of the POE method in electrostatic and electric current units and the study of its effectiveness].* Unpublished Master's Thesis. Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü. Trabazon.

Moursund, D. (2003). *Project-based learning: Using Information Technology*. ISTE.

Nachmias, D., & Nachmias, C. (1997). *Research methods In the social science*. St. Martin's Press.

Noordin M. K., Nasir, A. N., Ali, D.F., & Nordin, M.S. (2011). Problem-based learning (PBL) and project-based learning (PjBL) in engineering education: A comparison. Proceedings of the IETEC'11 Conference, Kuala Lumpur, Malaysia. https://www.researchgate.net/publication/229036490_Problem-Based_Learning_PBL_and_Project-Based_Learning_PjBL_in_engineering_education_a_comparison

Örgün, E. (2002). *Lise Öğrencilerinin Elektrik Akımı Konusundaki Kavram Yanılgılarında Yapıcı Öğretim Yaklaşımının Etkisi [The effect of a constructivist teaching approach on students' misconceptions about electric current in high school]. Unpublished Master's Thesis.* Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul.

Pardhon, H., & Bano, Y. (2001). Science teachers' alternative conceptions about direct-currrents. *International Journal of Science Education,* 23(3), 301-318. https://doi.org/10.1080/095006901750066538

Psillos, D., Koumaras, P., & Tiberghien, A. (1988). Voltage presented as a primary concept in an introductory teaching sequence on DC circuits. *International Journal of Science Education,* 10 (1), 29-43. https://doi.org/10.1080/0950069880100104

Torp, L., & Sage, S. (2002). *Problem as possibilities: Problem-based learning for K–16 education*. Association for Supervision and Curriculum Development.

Saracaloğlu, A. S., Akamca, G. Ö., & Yeşildere, S. (2006). İlköğretimde Proje Tabanlı Öğrenmenin Yeri [Project-based learning in elementary education]. *Türk Eğitim Bilimleri Dergisi*, 4 (3), 241-258.

Seloni, R. Ş. (2005). *Fen Bilgisi Öğretiminde Oluşan Kavram Yanılgılarının Proje Tabanlı Öğrenme İle Giderilmesi [*Resolving the misconceptions in science education by project-based learning approach]. Unpublished Master's Thesis, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Sencar, S., & Eryılmaz, A. (2002). Dokuzuncu Sınıf Öğrencilerinin Basit Elektrik Devreleri Konusuna İlişkin Kavram Yanılgıları [Misconceptions of ninth-grade students about simple electric circuits]. *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Bildirileri, ODTÜ, Ankara, 577-582.*

Sert Çıbık, A., & Emraoğlu N., (2008). Proje Tabanlı Öğrenme Yaklaşımının Fen Bilgisi Dersinde Öğrencilerin Mantıksal Düşünme Becerilerinin Gelişimine Etkisi [The effect of project-based learning approach on the development of logical thinking skills of students in science course]. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, Cilt 17, Sayı 2, 51-66

Shipstone, D.M., Rhöneck, C.V., Jung, W., Karrqvist, C., Dupin, J., Joshua, S., & Lieht, P. (1988). A study of secondary students' understanding of electricity in five European countries. *International Journal of Science Education,* 10(3),303- 316. https://doi.org/10.1080/0950069880100306

Schmidt, K. L., & Fisher J. C. (1992). Effective development and utilization of self learning models. *The Journal Of Contınuing Education in Nursing,* 43(2). https://doi.org/10.3928/0022-0124-19920301-05

Sönmez, G., Geban, Ö., & Ertepınar, H. (2001). Altıncı Sınıf Öğrencilerinin Elektrik Konusundaki Kavramları Anlamalarında Kavramsal Değişimin Etkisi [The effect of conceptual change on sixth-grade students' understanding of concepts about electricity]. *Fen Bilimleri Eğitimi Sempozyumu Bildirileri, Maltepe Üniversitesi, istanbul. 35-38.*

Şahin N. Şahin N. H., & Heppner P. P. (1993). Psychometric properties of the problem solving inventory in a group of Turkish university students. *Cognitive Therapy and Research*, 17 (4), 379-396. https://doi.org/10.1007/BF01177661

Şahin, M. (2009). Exploring university students' expectations and beliefs about physics and physics learning in a problem-based learning context. *Eurasia Journal of Mathematics, Science & Technology Education,* 5(4), 321-333. https://doi.org/10.12973/ejmste/75283

Tuncer, M., (2009). Proje Tabanlı Öğrenme İle Problem Tabanlı Öğrenmenin Fark ve Benzerlikleri [The similarity and differences of project based learning and problem based learning]. *E-Journal of New World Sciences Academy*, 4(2), 395-409.

Uysal, Ö. (2016). Harmanlanmış Öğrenme Ortamında Proje Tabanlı Öğrenmenin Gerçekleştirilmesi [Realization of project-based learning in a mixed learning environment]. *Açıköğretim Uygulamaları & Araştırmaları Dergisi*, 2(2), 89-113.

Yaman, S. (2005). Fen Bilgisi Eğitiminde Probleme Dayalı Öğrenmenin Mantıksal Düşünme Becerisinin Gelişimine Etkisi [The effect of problem-based learning on the development of logical thinking skills in science education]. *Türk Fen Eğitim Dergisi*, 2(1), 56–70.

Yavuz, S., & Yavuz, G. (2017). Fen Eğitiminde Proje Tabanlı Öğretimle İlgili Tezlerin İçerik Analizi: Türkiye Örneği (2002-2014) [A content analysis related to theses of project-based learning in science education: The case of Turkey (2002-2014)]. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi,* 0 (43), 255-282.

Yıldırım, A., & Şimşek, H., (2008). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri [Qualitative research methods in social sciences].* Seçkin Yayıncılık.

Wood, D.F. (2003). ABC of learning and teaching in medicine: Problem based learning. *British Medicine Journal,* 326, 328-33. https://doi.org/10.1136/bmj.326.7384.328

Sabri Kan
Physics Department
Ataturk Science and Art Centre
Adnan Menderes Mahallesi İspinoz Sokak No 16/2,
77200 Yalova, Turkey
sabrikan@hotmail.com

Ahmet Zeki Saka
Physics Department
Faculty of Education
Trabzon University
Fatih Eğitim Fakültesi, Söğütlü Mahallesi Adnan
Kahveci Bulvarı, Akçaabat,
61335 Trabzon, Turkey
azsaka@gmail.com

Uspoređivanje metoda učenja utemeljenoga na problemskom i projektnom učenju u nastavi Fizike

Sažetak

Cilj je ovoga istraživanja usporediti primjenu projektnoga učenja (Project Based Learning - PjBL) i problemskoga učenja (Problem Based Learning - PBL) u nastavi Fizike na osnovi razvoja učeničkih postignuća, razvoja vještina rješavanja problema (Problem Solving Skills - PSS) i analizi područja primjene. Ovo istraživanje provedeno je metodom osobite situacije s 48 učenika 9. razreda na satu Fizike, obrađujući temu „Elektricitet i magnetizam" u Prirodoslovnoj gimnaziji u turskoj Mramornoj regiji. U ovom istraživanju korištena su kvantitativna i kvalitativna sredstva za prikupljanje podataka. Kvantitativni podatci analizirani su pomoću statističkoga programa SPSS. Kvalitativni podatci su evaluirani koristeći sadržajnu analizu i analizu dokumenata. Rezultati upućuju na to da je primjena metode projektnoga učenja učinkovitija u odnosu na primjenu problemskoga učenja. Osim toga, obje metode doprinose poboljšanju učeničkih postignuća, njihova interesa za fiziku i odgovornosti prema učenju fizike. Prema rezultatima istraživanja, nastavnici Fizike trebali bi ispuniti potrebni korak prikupljanja informacija i obratiti pozornost na usaglašenost grupa koje će biti formirane u učionici pri primjeni metoda projektnoga učenja (PjBL) i problemskoga učenja (PBL).

Ključne riječi: *elektricitet i magnetizam, natava Fizike; problemsko učenje; projektno učenje; rješavanje problema; vještine.*

Uvod

Odgovarajući razvoj i primjena nastavnih programa u skladu s potrebama učenika određene dobi kako bi suvremeni nastavni proces doprinio njihovu svekolikom razvoju. Nastavni program Fizike koji je pripremilo Ministarstvo obrazovanja, usmjeren je na pravilan prijelaz između osnovne i srednjoškolske nastave.

Ključni pojmovi u nastavnom programu prirodnoslovnih predmeta čine važnu osnovu za temeljno znanje učenika o satu Fizike. Uz spiralni pristup u nastavi, uspjesi u okviru vještina znanstvenih procesa, znanosti, tehnologije, društva, okoliša, stava i vrijednosti utemeljili su važna razmišljanja za novi nastavni program Fizike (Ministarstvo nacionalnoga obrazovanja, 2007). Može se reći da se Nastavni program Fizike fokusira na dvosmjerni cilj u dimenziji znanja i stjecanja vještina.

Istraživanja pokazuju da korištenje pogrešne nastavne metode u nastavi fizike u mnogome se odražava na razumijevanje predmeta Fizike (Elby, 1999; Ayvacı i Bebek, 2018; Inac i Tuksal, 2019). Posljednjih godina sve češće svoje mjesto u nastavi Fizike imaju projektno učenje (PjBL) u kojem su učenici izloženi problemu iz svakodnevnoga života i koje zahtijeva od njih da razviju prijedloge rješenja kao i primjenu problemskoga učenja (PBL) (Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M. i Palincsar, A., 1991; Diggs, 1999; Duch, B. J., Groh, S. E. i Allen, D. E., 2001; Korkmaz, 2002; Şahin, 2009; Demirel, M. i Arslan Turan B., 2010). Projektno učenje je nastavna metoda kojoj je cilj da učenici pojedinačno ili u malim grupama rade na rješavanju problema. Drugim riječima, to je metoda koja stavlja u središte prelazak učenika iz pasivnoga primatelja informacija u kreativne pojedince koji istražuju, ispituju, pristupaju znanju i rješavaju probleme sa saznanjima koje posjeduju, neovisno razmišljaju u procesu učenja i poučavanja (Schmidt, KL i Fisher JC, 1992). Jedna od važnih prednosti ove metode je to što pruža svijest o odgovornosti kod pojedinaca koji preuzimaju dužnosti u grupama (Moursund, 2003). Prema podatcima dobivenim iz različitih studija (Bilen 2002; Erdem, 2002; Korkmaz, 2002; Yaman, 2005; Boyle i Rigg, 2006; İçelli, 2007; Kılınç, 2007; Sert Çıbık i Emrahoğlu, 2008; Tuncer, 2009-Grant, 2002; Tuncer, 2009; Noordin, 2011; Kan, 2013; Uysal 2016), moguće je usporediti PjBL i PBL metode kako je prikazano u Tablici 1 u uspoređujući njihove sličnosti i razlike.

Tablica 1.

Provedene studije ukazuju na to da su prvi primjeri metode projektnoga učenja zabilježeni u radu Protagore i Aristotela. Howard Borrows je prvi put izveo ozbiljnu primjenu ove metode u Kanadi 1976. godine na Medicinskom fakultetu Sveučilišta McMaster. Ova primjena kasnije je prihvaćena na mnogim sveučilištima na dodiplomskim i diplomskim studijskim programima kao što su Američka medicinska škola u 1970., Sveučilište Roskilde u 1972., Sveučilište Aalborg 1974., Koledž Olin 1997. (kao što je citirano u Korkmaz, 2019 i u Graaff i Kolmos, 2007). Projektno učenje, u današnjem obrazovnom sustavu, ima šire područje primjene u nastavi, posebno u osnovnom i srednjoškolskom obrazovanju te u medicini, inženjerstvu, studiju jezika, arhitekturi i pravu (Howell, 2003; Coşkun, 2004).

U Turskoj, u periodu između 2008. i 2013. god., učinjene su bitne promjene u nastavnom programu fizike, koji dugo nije bio mijenjan. Ovim promjenama nastavnici su dobili nove odgovornosti poput primjenjivanja novih načina učenja i poučavanja te odlučivanja o tome koja od tih metoda bi zaista mogla osigurati učinkovito izvođenje sata. Ove nove odgovornosti postale su još važnije za nastavnike zbog mnogih postojećih apstraktnih pojmova u nastavi Fizike. U literaturi postoje brojne studije koje ukazuju na to da su projektno i problemsko učenje učinkovitije u poučavanju apstraktnih pojmova (Harland, 2002; Harris, K., Marcus, R., McLaren, K. i Fey, J., 2001; Kaptan, F., 2002; Mayer, 2002; Seloni, 2005). Međutim, nedovoljan odgovarajući broj primjera primjene metoda projektnoga i problemskoga učenja u nastavi Fizike govori da je potrebno posvetiti više pažnje istraživanjima na ovom području.

Osnove lekcije „Elektricitet i magnetizam" počinju u osnovnom obrazovanju. U mnogim studijama o ovoj temi naglašeno je da učenici pojmove u ovim lekcijama navode kao teške i složene (Asomi, N., King, J. i Monk, M., 2000 .; Cohen, R., Eylon, B. i Ganiel, U., 1982; Çıldır, I. i Şen, A. İ., 2006; Duit, R. i Rhöneck, C., 2007; Frederiksen, JR, White BY i Gutwill, J., 1999; Heller, PM i Finley, FN, 1992; Küçüközer, 2003; Örgün, 2002; Pardhon, H. i Bano, Y., 2001; Psillos, D., Koumaras, P. i Tiberghien, A., 1988; Sencar, S. i Eryılmaz, A., 2002; Shipstone, DM, Rhöneck, CV, Jung, W., Karrqvist, C., Dupin, J., Joshua, S. i Lieht, P., 1988; Sönmez, G., Geban, Ö. i Ertepınar, H., 2001). Budući da tema „elektricitet" uključuje egzaktne pojmove i matematičke operacije (struja, napon, razlika potencijala, otpor itd.), kao takva čini opsežno gradivo nastave Fizike. Iz tog razloga, očekuje se da će ova studija doprinijeti popunjavanju praznine u ovom području. S druge strane, nepostojanje bilo kakvih studija u Turskoj za usporedbu primjene PjBL i PBL metoda, dodatno povećava važnost ovoga istraživanja.

Posljednjih godina primjene projektnoga i problemskoga učenja u turskom obrazovnom sistemu su bile među učinkovitim metodama koje bi se mogle koristiti za postizanje ciljeva u nastavi fizike sa sve većom popularnošću (Yavuz i Yavuz, 2017). Iako su dostupne metaanalize ovih metoda (Üstün, 2012), u literaturi se ne nalaze često usporedne studije o aktivnoj uporabi istih kako bi se utvrdio učinak ove dvije metode u nastavi Fizike. Predviđeno je da će usporedne studije provedene na tom polju doprinijeti evaluaciji primjene u pogledu pronalaska odgovarajućih materijala za nastavu Fizike. Očekuje se da će rezultati dobiveni ovom studijom pomoći nastavnicima fizike u shvaćanjima koja će se metoda učinkovitije koristiti u općem smislu u nastavi, te konkretno u obradi tematike elektriciteta. U tom pogledu cilj je provedenoga istraživanja usporediti praktičnu primjenu projektnoga i problemskoga (PjBL-a i PBL–a) učenja u nastavi Fizike. U tu svrhu u okviru provedenoga istraživanja tražit će se odgovori na sljedeća pitanja:

1. Koja je od metoda, projektno učenje ili problemsko učenje, efikasnija u pogledu poboljšanja postignuća učenika na satu Fizike?
2. Koja je metoda efikasnija u pogledu razvoja učeničkih vještina rješavanja problema (PSS-a)?
3. Koja je metoda korisnija od analize područja primjene?

Metoda

U ovom istraživanju, na temelju mješovite metodologije iz društvenih znanosti, korištene su zajedno kvalitativne i kvantitativne metode prikupljanja podataka. Efekt svake pojedinačne varijable projektnoga i problemskoga učenja u pogledu grupnoga razvoja vještine rješanja problema ispitan je testovima prije i poslije. Kvantitativni podatci dobiveni su primjenom tipa polueksperimentalne studije. Eksperimentalne studije definirane su kao istraživački projekti koji se koriste za istraživanje uzročno-posljedičnih veza između varijabli (Büyüköztürk, 2007). Polueksperimentalna istraživanja provode se na veoma sličan način. Međutim, u polueksperimentalnim studijama potrebno je oformiti određene skupine na osnovi ciljanoga, a ne slučajnoga odabirom (Ekiz, 2003; Karasar, 2006). U ovoj studiji obraćena je pozornost na to da formiranje grupa u kojima će se provoditi metode projektnoga i problemskoga učenja nije slučajno, već da ih čine učenice srednje škole homogenih karakteristika u skladu s njihovim postignutim prijemnim rezultatima.

Istraživači pridaju važnost realizaciji kratkoročnih primjena kako bi mjerili učinak pojedinačne varijable u takvim studijama (Cohen, L. i Manion L., 1994; Nachmias, D. i Nachmias, C., 1997; Karasar, 2006 ; Mısır, 2009).

Kvalitativni podatci ove studije prikupljeni su opažanjima provedenim u procesu primjene, analizom nastavnoga materijala, neformalnim intervjuima i intervjuom licem u lice obavljenim na kraju studije.

Studijska grupa

U ovo istraživanje uključeno je na 48 učenika 9. razreda Prirodoslovne gimnazije u turskoj Mramornoj regiji u drugom polugodištu 2010./2011. školske godine. Jedan uzorak je bio razred s 24 učenika gdje je primjenjena metoda projektnoga učenja, a drugi razred također s 24 učenika gdje je primijenjena metoda problemskoga učenja. U okviru istraživanja, kako bi se procijenila ekvivalentnost dviju skupina, korištene su dvije vrste podataka: prosječne ocjene iz predmeta Fizike u prvom polugodištu školske godine kada se studija provodila te rezultati prijemnoga ispita za srednje škole. Kao rezultat ispitivanja provedenoga putem nezavisne analize t-testa, utvrđeno je da nema značajne razlike između ocjena učenika iz Fizike i ocjena uspješnosti na prijemim ispitima za srednju školu ($p > ,05$) te da se ta dva razreda sastoje od jednakih skupina.

Rezultati neovisnih rezultata t-testa za ocjene Fizike učenika u uzorku, njihove demografske karakteristike, broj sudionika u skupinama i primijenjenu nastavnu metodu prikazani su u Tablici 2.

Tablica 2.

Tehnike prikupljanja podataka

Potrebne dozvole pribavljene su od Pokrajinske uprave za nacionalno obrazovanje za sve tehnike korištene za prikupljanje podataka u istraživanju. U nastavku dan je kratak uvod u korištene instrumente za prikupljanja podataka u ovom istraživanju.

Inventar rješavanja problema (Problem Solving Inventory - PSI): Ovaj upitnik koji se koristio kao predtestiranje i poslijetestiranje razvili su Heppner i Peterson (1982). Upitnik čiji je izvorni naziv Inventar za rješavanje problema, obrazac-A (PSI-A) adaptirali su na turski jezik Şahin N., Şahin N. H. i Heppner P. P. (1993). Skala koja se sastoji od 35 stavki u obliku je Likertove skale od 6 točaka. Od toga 32 stavke uključene su u evaluaciju, 16 ukazuje na pozitivne, a 16 na negativne sudove. U ovom istraživanju, 3 stavke koje su postojale u inventaru, ali nisu postojale u nastavnom programu Fizike, isključene su iz evaluacije.

Test sposobnosti rješavanja problema (Problems Solving Skills Test - PSST): Ovu skalu razvili su istraživači kako bi odredili razinu od 13 vještina rješavanja problema u nastavnoj jedinici „Elektricitet i magnetizam", uključenoj u nastavni program Fizike. Dva akademika i osam nastavnika za studije razmjera, valjanosti i pouzdanosti u dvije pilot-primjene koristili su: pregled opsega, studije kompatibilnosti i paralelizma. U okviru provedenih pilot-studija, PSST koji se sastojao od otvorenih pitanja primijenjen je na ukupno 108 učenika. Uzimajući u obzir podatke dobivene iz pilot-primjena, pitanja koja je bilo teško razumjeti preuređena su bez promjene karakteristika koje predstavljaju relevantne vještine rješavanja problema. Učenici su u ovom testu odgovorili na pitanja o osnovnom znanju o struji, sjaju svjetiljki, otporu vodiča, razlici potencijala, funkcijama strujnih krugova, Ohmovom zakonu, zaključcima iz strujnih eksperimenata, trenutačnom i potencijalnom proračunu i ekvivalentnom otporu.

Skala koja se koristila kao pred i poslijetestiranje sastoji se od 10 otvorenih pitanja. Ne postoje čimbenici koji bi ugrozili valjanost strukture na otvorenim skalama prema Likertu ili skali s višestrukim izborom (Güler, 2014). S druge strane, na takvim otvorenim skalama gdje se točan odgovor ne prikazuje unutar mogućnosti, učinkovitije se utvrđuju stvarne vještine učenika. U ovom je istraživanju utvrđeno da je koeficijent pouzdanosti skale 0,76. U bodovanju za PSST davani su bodovi 2, 1 i 0 za potpuno točne odgovore, djelomično točne odgovore i pogrešne odgovore. U tom pogledu, najveći rezultat koji je učenik mogao postići bio je 20 (10 x 2).

Skala stava prema satu Fizike (Physics Course Attitude Scale - PCAS): Ovu skalu, koja je adaptacija Skale stava prema satu prirodoslovnih predmeta, razvili su Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A. i Şahbaz, F. (1994). Čini je 15 pitanja koja su korištena kao predtestiranje i poslijetestiranje, a kako bi se utvrdilo zanimanje učenika za predmet Fizike. Ova skala čiji je kvocijent pouzdanosti izračunat na 0,82 u obliku je Likertove ljestvice s 5 bodova s odgovorima od „U potpunosti se slažem" do „U potpunosti se ne slažem".

Intervju „licem u lice": U okviru istraživanja, metoda intervjua „licem u lice" korištena je zbog značajki koje istraživaču pružaju širok raspon fleksibilnosti, dopuštajući studentima da pomno istraže svoje pogreške i stvaranje prilike za istraživanje neobične situacije koja je u prvom planu tijekom procesa rješavanja problema. Nakon zavšenih primjena u sklopu istraživanja, provedeni su polustrukturirani intervjui „licem u lice" s 5 učenika koji su namjerno odabrani kao predstavnici grupa koje su sudjelovali u primjenama projektnoga i problemskoga učenja (PjBL i PBL). Primjene koje su provedene u okviru 3 temeljna pitanja urađene su da bi se saznali rezultati postignuti tijekom procesa primjene, a u isto vrijeme i stavovima prema predmetu Fizika i razmišljanjima učenika o provedenim primjenama .

Vodič za sate projektnoga i problemskoga učenja: Prije primjene, svaki učenik u obje grupe dobio je jedan letak koji je izradio istraživač. U ovom materijalu za primjenu uzeti su u obzir koraci metode projektnoga učenja koje su razvili Korkmaz (2002) i Moursund (2003) te proces od ukupno sedam koraka s tri glavne faze. S druge strane, letak problemskoga učenja, koji je pripremljen u okviru studije kao sinteza koraka primjene koje su predložili Wood (2003) i Jonhson (2003), sastoji se od ukupno 23 stranice. Uzimajući u obzir postignuća nastavne jedinice „Elektricitet i magnetizam" u nastavnom programu, vodiči pripremljeni prema novim koracima primjene projektnoga i problemskoga učenja (PjBL -a i PBL –a), koji su dolje navedeni, prvo su testirani putem pilot-studije, a problemi identificirani u ovoj primjeni riješeni su i ovaj je materijal dobio konačni oblik.

Opažanje: U studiji su provedena neformalna opažanja koja su imala za cilj utvrditi bihevioralne odgovore učenika u nastavnom okruženju povezanom s primjenom. Zapažanja su zapisana u dnevnim bilješkama istraživača. Ista su povezana s odgovorima učenika na primijenjenu nastavnu metodu i njihovim stavovima prema satu Fizike.

Primjena

Ovo istraživanje provedeno je u periodu od 7 tjedana. Istraživač je u prvom tjednu dobio dopuštenje Pokrajinske uprave za nacionalno obrazovanje, predstavio metode projektnoga i problemskoga učenja (PjBL-a i PBL-a) te proveo predtestiranje i formirao studije za razrede, odnosno grupe. Dva puta tjedno u periodu od 5 tjedana održavani su sati o temi „Elektiricitet i magnetizam" u dva odabrana razreda. U posljednjih tjedan dana primijenjeni su poslijetestovi te su obavljeni intervjui „licem u lice" i evaluacija. Istraživač je proveo sve primjene, a tijekom istih predmetni nastavnici u školi sudjelovali su kao promatrači.

Provođenje metode projektnoga učenja

Primjena projektnoga učenja u nastavnim okruženjima može se analizirati kroz tri glavne faze za ovo istraživanje. Riječ je o ovim fazama: uvod, priprema i istraživanje te prezentacija i rasprava. U prvoj od ovih faza aktivni su profesori, u drugoj učenici, a u trećoj i profesori i učenici. Učenicima na koje je metoda primijenjena, prvo je predstavljena metoda projektnoga učenja. Razred u kojem je metoda primijenjena bio je podijeljen u 5 različitih grupa. Svaka grupa dobila je, u vidu dokumenata, po jednu temu iz lekcije „ELektricitet i magnetizam" za projektni zadatak. U ovim dokumentima dane su informacije o koracima koje treba pratiti u projektnom radu i o datumima izlaganja urađenoga. Način provođenja projektnoga učenja dana je u Tablici 3.

Tablica 3.

Provedba problemskoga učenja

U općem smislu, problemsko učenje je metoda učenja čija se primjena temelji na suradnji. U okviru ovoga istraživanja provedene su probne primjene kako bi se ispitala usklađenost između teorije, informacija i aktivnosti primjena. U slučajevima na kojima je primijenjeno problemsko učenje, razvijena je metoda primjene od osam koraka prema Wood (2003) i Johnsonovim (2003) koracima primjene. Slično primjenama projektnoga učenja, prije primjene problemskoga učenja učenicima je prezentirana ova metoda. Na kraju prezentacije formirane su grupe za učenje podjelom učenika u 5 timova. Nakon ovoga prvog koraka problemskoga učenja, svi ostali koraci provedeni u nastavnom okruženju. Koraci problemskoga učenja razvijeni za istraživanje i izvršeni rad prikazani su u Tablici 4.

Tablica 4.

Kao što je vidljivo u Tablici 4 svi razvijeni koraci usmjereni su na osmišljavanje metode problemskoga učenja na način da se može izvesti u učionici. Istraživač je riješio problem dosezanja izvora informacija u nastavnim okruženjima osiguravajući udžbenike, računala i pristup internetu u laboratorijskom okruženju. Tako je učinak nekontroliranih varijabli u okruženju u kojem se primjenjuje problemsko učenje sveden na minimum.

Prikupljanje i analiza podataka

U okviru istraživanja, primjene projektnoga i problemskoga učenja u svakom razredu prepoznate su kao neovisna varijabla, dok su vještine učenika u rješavanju problema i nastavna postignuća prepoznati kao ovisna varijabla. Analiza instrumenata za prikupljanje podataka korištenih u ovoj studiji detaljno je razmotrena u nastavku uzimajući u obzir ove informacije.

Analiza podataka Inventara rješavanja problema (PSI) i Testa sposobnosti rješavanja problema (PSST): Statistički program SPSS 22.0 korišten je u analizi Inventara rješavanja problema (PSI) i Testa sposobnosti rješavanja problema (PSST), koji su bili u funkciji predtesta i poslijetesta. Kako bi se odlučilo kojim će se testovima analizirati dobiveni podatci, utvrđena je razina normalnosti podataka. Razine normalnosti Inventara rješavanja problema (PSI) predtesta je 0,668, a razine normalnosti poslijetesta 0,724. Zbog parametrijskih svojstava dobivenih podataka, upareni uzorak t-testa koristio se u analizi podataka za usporedbe unutar grupa, a neovisni t-test za usporedbu unutar grupa (Akbulut, 2010).

Prema analizama, određena je Wilkova lambda vrijednost kako bi se utvrdio zajednički učinak te je usvojena 0,05 razina značajnosti. Osim toga, razina sposobnosti učenika u rješavanju problemskih zadataka (PSS) analizirana je na osnovi podataka dobivenih Testom sposobnosti rješavanja problema (PSST) i analizom sadržaja.

Analiza podataka Skale stava prema satu Fizike (PCAS): Analiza Skale stava prema satu Fizike (PCAS) bila je ograničena samo na osnovne statističke podatke.

Analiza intervjua i zapažanja „licem u lice“: Preinačavanjem intervjua *licem u lice* s učenicima koji sudjeluju u primjeni u pisani oblik metodom dekodiranja, slični i različiti odgovori na svako pitanje analizirani su prvenstveno njihovim unošenjem u tablicu. Isti ili slični izrazi u tablici preoblikovani su u jedan izraz ispravljanjem pravopisnih pogrešaka. Neformalna opažanja koja je istraživač proveo zabilježena su u dnevnim napomenama te su se uzela u obzir za pouzdanost podataka.

Dok se deskriptivna analiza koristi u obradi podataka koji ne zahtijevaju dublju analizu, analiza sadržaja zahtijeva pomnije ispitivanje dobivenih podataka i pristup pojmovima i temama koji opisuju te podatke (Yıldırım, A. i Şimşek, H., 2008). Intervjui *licem u lice* provedeni u ovom istraživanju sa šest učenika iz svake grupe na kraju primjene projektnoga i problemskoga učenja (PjBL-a i PBL-a) kategorizirani su kodifikacijama u koje su svrstani slični izrazi. Mreža je uspostavljena kako bi se utvrdilo prema kojem su kodu, temi ili sposobnosti rješavanja problema usmjereni izrazi koje koriste učenici u obje grupe u intervjuu. Tako je omogućena usporedba između primjera učestalosti i kodiranja izraza koji su podvrgnuti analizi sadržaja u intervjuima *licem u lice* u smislu kvalitete i kvantitete.

Analiza materijala za primjenu koji su koristili učenici za projektno i problemsko učenje: Relevantna područja za odražavanje učeničkih sposobnosti rješavanja problema na primijenjenom materijalu ispitana su opisnom metodom analize pomoću analize dokumenata. Primjeri za ova područja mogli biti: imenovanje problema na temelju razumijevanja projektnoga predmeta i zadanoga scenarija, određivanje varijabli izgradnjom hipoteze, postizanje generalizacija iz podataka i testiranje učinka varijabli na modelu.

Rezultati

Normalna raspodjela pronađena je u analizi normalnosti Inventara rješavanja problema u kojem je razina sposobnosti rješavanja problema učenika ocijenjena s 32 stavke. Utvrđeno je da je Cronbachov alfa kvocijent Inventara rješevanja problema korišten u opsegu studije 0,86. Analiza je provedena isključenjem tri stavke ove ljestvice (9, 22, 29) koje nisu imale za cilj mjerenje sposobnosti rješavanja problema i reorganizacijom stavki koje su odražavale negativan sud obrnutim kodiranjem. Budući da p vrijednost Boxova M-testa ispitanoga u ovoj analizi nije bila značajna, ispunjena je jednakost kovarijantnoga uvjeta. Također, utvrđeno je da je korelacija između varijabli u grupama jednaka i da su varijance homogene prema testu homogenosti skala Inventara rješavanja problema i Testa sposobnosti rješavanja problema.

Tablica 5.

Tablica 5 pokazuje da primjene projektnoga i problemskoga učenja imaju pozitivne učinke na učeničke sposobnosti rješavanja problema u razredima u kojima su primjenjene ($P < ,05$). S druge strane, kao što se vidi iz tablice, prosječna vrijednost predtesta provedena s učenicima prije primjene projektnoga učenja iznosi 6,375, dok je prosječna vrijednost poslijetesta za Test sposobnosti rješavanja problema 13,958.

Tablica 6.

Kao što se vidi u Tablici 6, prisutna je značana razlika između prosjeka Testa sposobnosti rješavanja problema (PSST) ($p = .021$ i $p < ,05$).

Kao što se vidi u tablicama 5 i 6, test Inventara rješavanja problema (PSI test) pokazuje da nema značajne razlike u razvoju sposobnosti rješavanja problema učenika koji sudjeluju u primjenama projektnoga i problemskoga učenja (PjBL i PBL). Prema podatcima Testa sposobnosti rješavanja problema (PSST-a), vještine rješavanja problema učenika koji sudjeluju u projektnom učenju značajno su se poboljšale u odnosu na one koji sudjeluju u primjeni problemskoga učenja. Utvrđeno je da nema značajne razlike između ocjena učenika koji su sudjelovali u primjenama projektnoga i problemskoga učenja u predtestu ove ljestvice.

Utvrđeno je da su vrijednosti poslijetesta učenika koji sudjeluju u primjenama projektnoga i problemskoga učenja veće od njihovih vrijednosti predtesta. S druge strane, osim za pitanja 6 i 8, razvoj sposobnosti učenika koji sudjeluju u primjeni projektnoga učenja na višoj je razini od učenika koji sudjeluju u primjenama problemskoga učenja. Štoviše, vidljivo je da su veći broj točnih izraza koji odražavaju sposobnost rješavanja problema upotrijebili u 8 pitanja učenici koji su sudjelovali u primjenama projektnoga učenja i u 2 pitanja učenici koji su sudjelovali u primjenama problemskoga učenja. Podatci dobiveni iz Skale stava prema satu Fizike (PCAS) kojom se utvrđuju razmišljanja i stavovi učenika koji sudjeluju u primjenama sata Fizike prikazani su u Tablici 7.

Tablica 7.

Prema saznanjima iz Tablice 7, dolazi se do zaključka da su se stavovi učenika koji sudjeluju u primjenama projektnoga učenja više razvili u pozitivnom smjeru. Opisne statistike poslijetestova Inventara rješavanja problema PSI i Testa sposobnosti rješavanja problema PSST prikazane su u Tablici 8.

Tablica 8.

Kao što se vidi iz Tablice 8, prosjeci Testa sposobnosti rječavanja problema učenika koji su sudjelovali u primjenama projektnog učenja porasli su sa 119,21 na 153,21. Sličan porast primijećen je u prosječnom uspjehu učenika koji sudjeluju u primjenama problemskoga učenja (sa 137,63 na 156,71). Međutim, vidi se da učenici koji sudjeluju u primjenama projektnoga učenja povećali (50,10 %) ove vještine više od onih koji su sudjelovali u primjeni problemskoga učenja (21,67 %).

Intervjui *licem u lice* provedeni u okviru istraživanja ispitani su kroz opisnu i sadržajnu analizu. Mreža odnosa PSS3 je prikazana u Prilogu 1, kao primjer ovoj analizi. Kodovi dobiveni iz odnosnih mreža prema Sposobnostima rješavanja problema u okviru lekcije „Elektiricit i magnetizam“ te frekvencije dobivene iz ovih kodova prikazani su u Tablici 9.

Tablica 9.

Kao što se vidi u Tablici 9, kada se usporede vrijednosti frekvencija proizvedenih/ostvarenih tema, u pogledu sposobnosti, osim za PSS6, utvrđeno je da učenici koji sudjeluju u primjenama projektnoga učenja imaju točnije izraze od učenika koji sudjeluju primjenama problemskoga učenja.

Druga tehnika za prikupljanje podataka u ovoj studiji su zapažanja. Ispostavilo se da općenito učenici koji sudjeluju u primjenama projektnoga i problemskoga učenja ne odražavaju očekivana postignuća u opsegu istraživanja u prvom tjednu primjene. Kada se ispitaju podatci koji se odnose na posljednji tjedan primjene projektnoga učenja, utvrđuje se da su se sva postignuća osim tri odrazili na nastavno okruženje učenika. Međutim, utvrđeno je da iako su učenici koji su sudjelovali u primjeni problemskoga učenja odražavali neke vještine i ponašanja testirana u nastavnom okruženju, neka od istih nisu prenesena u nastavno okruženje.

Evaluacija zapažanja koja je istraživač proveo i zabilježio u dnevnim napomenama posljednjih tjedan dana promatranja učenika koji su sudjelovali u primjeni projektnoga učenja:

„Prezentacija koju je pripremila projektna grupa uspješno je implementirana u nastavno okruženje. Iako su problemi nastali tijekom procesa izrade modela, to je pomoglo drugim grupama da dobiju važne informacije o načinu rada elektromotora. Također je primijećeno da su ostale grupe postavljale pitanja o modelu. U ovotjednim primjenama primijećeno je da učenici ispravno shvaćaju pojam varijable i da ga ispravno koriste u svojim razgovorima."

S druge strane, bilješke istraživača o posljednjem tjednu primjene problemskoga učenja predstavljene su u nastavku:

„Uočeno je da su se učeničke grupe potpuno prilagodile primjenama. Uočeno je da je komunikacija unutar i između grupa bolja. Još jedna uočljiva situacija u ovotjednim primjenama je da grupe u potpunosti i pravilno koriste nastavni materijal koji se primjenjuje tijekom nastavnoga sata te da uspješno primjenjuju korake problemskoga učenja ispravnim redoslijedom."

U konačnici, utvrđeno je da su se učenici koji su sudjelovali u primjeni projektnoga učenja u kraćem vremenu priviknuli na ovu metodu, dok je vrijeme prilagodbe učenika koji su sudjelovali u primjeni problemskoga učenja bilo duže.

Utvrđeno je da postoji općenito jedinstvo u korištenju primijenjenoga nastavnog materijala projektnoga i problemskoga učenja razvijenoga za studijsku primjenu i stvaranje jedinstva u korištenom uzorku upotrebljenom od strane učeničkih grupa. U prva dva koraka primjenjivanja materijala razvijenih na temelju metoda pojektnoga i problemskoga učenja, od učenika nije zahtijevan nikakav rad.

Dio za istraživanje informacija zajednički je dio uključen u materijal primjene obje metode. U ovom dijelu učenici su dužni provesti istraživanje o ciljevima učenja. Utvrđeno je da su učenici pravilno završili ovaj dio projektnoga i problemskoga učenja. Prema njihovim izjavama, učenici su pravilno završili određene dijelove nastavnoga materijala. Učenici koji su sudjelovali u primjeni projektnoga učenja dali su detaljnija objašnjenja u odnosu na učenike koji su sudjelovali u primjeni problemskoga učenja. Slično, u analizi dokumenata materijala drugih učenika koji su sudjelovali u primjenama, vidi se da su učenici koji su sudjelovali u primjeni projektnoga učenja pažljivije popunjavali ovaj dio o materijalima u odnosu na učenike koji su sudjelovali u primjeni problemskoga učenja.

U konačnici je utvrđeno je da su učenici koji sudjeluju u primjeni projektnoga i problemskoga učenja dovršili implementaciju primijenjenih materijala u skladu s ciljevima primijenjenih nastavnih metoda i nastavnim ciljevima. Međutim, utvrđeno je da su se učenici koji su sudjelovali u primjeni problemskoga učenja pažljivije ponašali tijekom dovršavanja materijala.

Rasprava, rezultat i implikacija

U ovom se istraživanju ponajprije želi usporediti primjena projektnoga i problemskoga učenja u nastavi Fizike. U literaturi se navodi da primjena projektnoga i problemskoga učenja značajno doprinose interakciji nastavnika i učenika, kao i interakciji među učenicima te poboljšanju vještina timskoga rada (Lee, C. I. i Tsai, F. Y., 2004). Ova je interakcija također primiječena u ovoj studiji. U provedenim primjenama uočeno je da metoda problemskoga učenja ima značajke koje pomažu učenicima predvidjeti što će raditi u nastavnom procesu i potiče planirano učenje u nastavnim okruženjima. Vidljivo je da primjena projektnoga učenja pruža učenicima mogućnost stvaranja originalnih djela, posebno u stvaralačkim zadatcima koji te da pružaju mogućnosti za prezentiranje njihovih individualnih sposobnosti poput, primjerice, rukotvorina. Međutim, potrebno je dodatno istaknuti da u primjeni problemske nastave do izražaja više dolaze usmena rješenja.

Kada se ocijene rezultati dobiveni instrumentima za prikupljanje podataka koji su korišteni u studiji, vidljivo je da primjena projektnoga učenja ima pozitivniji učinak na razvoj učeničkih sposobnosti rješavanja problema u odnosu na primjenu problemskoga učenja. S druge strane, pokazalo se da učenici koji sudjeluju u primjeni projektnoga učenja koriste ispravnije izjave u odnosu na one koji sudjeluju u primjeni problemskoga učenja, što je pokazatelj da primejna projektnoga učenja ima učinkovitiju ulogu u razvoju sposobnosti rješavanja problema.

Drugi podatak koji podupire ovo sazanje jest da je učestalost netočnih izjava koje koriste učenici koji sudjeluju u primjeni problemskoga učenja veća. Također, kvalitativni rezultati dobiveni iz Skale stava prema satu Fizike, koji je još jedan kvalitativni izvor podataka, ukazuju na to da primjene projektnoga učenja imaju pozitivniji učinak na stavove učenika prema satu Fizike u odnosu na primjene problemskoga učenja.

Druga dva pitanja postavljena u istraživanju uspoređuju učinke primjena projektnoga i problemskog učenja na razinu postignuća učeničkih sposobnosti rješavanja problema i nastavnih postignuća iz predmeta Fizika. Statistički rezultati tehnika prikupljanja podataka, koje su korištene u tu svrhu, pokazali su da obje metode nude pozitivan doprinos razumijevanju sata Fizike. Također, pokazalo se da obje metode doprinose većem interesu učenika za fiziku i razvoju nastavnoga uspjeha.

Tijekom intervjua *licem u lice* provedenih u svrhu istraživanja, stvorene asocijativne mreže predviđaju da će učenici koji sudjeluju u primjeni projektnoga učenja uspješnije odražavati takve sposobnosti. Međutim, u obje primjene učenici su pokazali aktivno sudjelovanje u procesu. Kako je shvaćeno iz saznanja temeljenih na opažanjima, učenici rado izvršavaju ove primjene. U tom smislu, u literaturi ističe se doprinos primjena projektnoga i problemskoga učenja u smislu povećanja učeničke motiviranosti za učenjem (Saracaloğlu A.S., Akamca G.Ö. i Yeşildere S., 2006; Gültekin, 2007; Hatısaru, V. i Küçükturan, A.G., 2009), potkrepljuje nalazima ove studije. S druge strane, saznanja studija Kaptana, F. i Korkmaza, H. (2002) te Gürlena (2011) pokazuju da obje metode imaju veći pozitivan učinak na razvoj sposobnosti rješavanja problema u odnosu na tradicionalne metode. Međutim, nepostojanje studije u literaturi koja bi pokazala koja je od ovih metoda učinkovitija od razvoja spomenutih sposobnosti čini rezultate dobivene istraživanjem vrijednim.

Kao rezultat, metode i projektnog a i problemskoga učenja imaju pozitivan učinak na razvoj sposobnosti rješavanja problema kod učenika. Međutim, moglo bi se reći da u usporedbi s metodom problemskoga učenja metoda projektnoga učenja ima veći utjecaj na razvoj ove sposobnosti. Ovaj rezultat dolazi do izražaja na kvalitativnoj skali. Učenici koji sudjeluju u primjenama projektnoga učenja poboljšavaju svoje sposobnosti rješavanja problema za 50 %, dok oni koji sudjeluju u primjenama problemskoga učenja poboljšavaju te sposobnosti za 21 %. Isti rezultat vrijedi i za napredatk uspjeha učenika na satu Fizike.

Razmatranjem dobivenih rezultata općenitije, utvrđuje se da učenici koji predstavljaju projekt u razrednom okruženju koje su pripremili putem primjene projektnoga učenja uspješnije koriste svoj rječnik, govor tijela i vještine slušanja. Ovaj doprinos projektnoga učenja stvara trajniji učinak na učenje nastavnoga materijala, posebice apstraktnih predmeta poput Fizike (Cengizhan, 2007; Ada, S., Baysal, Z. N. i Kadıoğlu, H., 2009). S druge strane, pokazalo se da primjene problemskoga učenja također značajno doprinose komunikacijskim vještinama učenika. Iznošenje prijedloga rješenja na temelju definiranih problema, rasprava o tim rješenjima u grupi i usporedba rješenja s prijedlozima rješenja iz drugih grupa jedna su od karakterističnih značajki problemskoga učenja (Torp, L. i Sage, S., 2002). U tom smislu, stvorene su mogućnosti da učenici svoje komunikacijske vještine pokažu tijekom nastavnoga procesa kroz primjenu problemskoga učenja.

Također, smatra se da natjecanje koje se pojavilo među grupama kako bi iznijeli svoje prijedloge rješenja ima pozitivan učinak na trajnost informacija koje treba naučiti, kao i na sam proces učenja.

Treći problem ovoga istraživanja odnosi se na dvojbu je li u nastavi Fizike metoda projektnoga ili metoda problemskoga učenja praktičnija i korisnija od analize okruženja primjene. Zbog toga obje metode privlače veću pozornost učenika u usporedbi s tradicionalnim metodama. No, u primjenama projektnoga učenja učenici se žale na nedostatak vremena.

Tijekom procesa neki problemi uzrokovani komunikacijom među učenicima otežavaju primjenu projektnoga učenja. Unatoč tome, utvrđeno je da učenici koji sudjeluju u primjenama projektnoga učenja pokušavaju predstaviti model. Utvrđeno je da su aktivniji u nastavi od onih koji sudjeluju u problemskom učenju. U tom smislu vjeruje se da projekto učenje pozitivno doprinosi i motivira u nastavnom procesu sata Fizike.

Prijedlozi predstavljeni na temelju kako općih rezultata, tako i pojedinačno za treći problem studije, navedeni su u nastavku:

Prije implementacije metoda projektnoga i problemskoga učenja, profesori bi trebali detaljno obavijestiti učenike o tim metodama kako bi se povećala razina njihovih utjecaja.

Primjene projektnoga i problemskoga učenja teške su za pripremu i kontrolu učionice, u odnosu na tradicionalne metode. Iz tog razloga profesori moraju izvršiti ozbiljnu pripremu za sat. Prije predavanja, trebali bi organizirati laboratorij i nastavno okruženje u skladu s koracima primjene ove dvije metode.

Profesori koji razmišljaju o implementiranju metoda projektnoga i problemskoga učenja trebaju formirati grupe koje mogu skladno raditi, uzimajući u obzir negativne situacije se mogu dogoditi među učenicima.

Utvrđeno je da neki scenariji problema koji se koriste u pilot-praksi i projektne teme ne privlače pozornost učenika te da postoji problem u primjeni obje metode. Stoga treba voditi računa o tome da se problemski scenariji i teme projekata koji će biti uključeni u nastavni materijal za primjene projektnoga i problemskoga učenja trebaju pripremiti tako da privuku pažnju učenika.