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The Effects of Project Based Learning on Undergraduate Students' Achievement and Self-Efficacy Beliefs Towards Science Teaching

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The purpose of this study is to investigate the effects of the Project-Based Learning (PBL) method on undergraduate students' achievement and its association with these students' self-efficacy beliefs about science teaching and pinions about PBL. The sample of the study consisted of two randomly chosen classes from a set of seven classes enrolled in the Science Teaching Course in a Primary School Education Department of a State University in Turkey. The randomly assigned treatment group (n =33) was instructed based on a PBL method. The control group (n = 33) was instructed through the use of a traditional teaching (TT) method. The Science and Technology Teaching Achievement Test (STTAT) and self-efficacy belief scale (SEBS) were used as pre- and post-test measures. The results showed that students in the treatment group produced better performance on the Post- SEBS and the Post-STTAT. The students in the treatment group expressed mostly positive opinions about the use of the Project-Based Learning method.

Keywords: project-based learning, science and technology teaching, achievement, self-efficacy, student opinions

INTRODUCTION

According to cognitive psychologists new knowledge is built when existing knowledge and ideas are actively used (Shuell, 1986). For effective teaching and learning and for the improvement of students in all aspects of skill development, the information that is taught, as well as, how it is taught, is important. Assimilation of knowledge by students has necessitated that students' learning be faster, more lasting and fruitful (Demirel, 2005). Several educators have described the learning process by stating that knowledge acquisition is related to experience. Knowledge gain is based on improvement of conceptual structures which are constantly developing from gained experience. Learning science depends on the experience of learning concrete thoughts initially, and then making those thoughts more complex and more applicable. Thus, teaching approaches should provide students with favorable environments to help them have more

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State of the literature

- Many types of student-centered learning approaches have been implemented in Science education in recent years.
- PBL is used as a strategy for research-based investigations to find solutions to daily life problems. In this approach, students taking responsibility for their own learning and working collaboratively with others, enhance their investigation and problem solving skills.
- In recent years studies have shown that teachers encounter some problems in using student-centered learning approaches in science courses. Hence, teachers need to acquire more experience in how to use project based learning strategies in science courses.

Contribution of this paper to the literature

- This study explores students' achievement and self-efficacy beliefs.
- Self-efficacy beliefs are important targets for individuals to decide for themselves and these beliefs affect the decisions of individuals on how much effort they should put into achieving their personal goals.
- Research improves pedagogical skills. High level skills entail document preparation, event development, and preparation of written and visual materials.
- Hence, this study aims to enhance the science education literature on PBL.

experience with understanding science processes. The importance of research methods in enhancing one's knowledge is acknowledged by all educators. The processes in education where learners ask their own questions, plan their research, analyze and express their own findings and structure their own understanding enable a more effective and lasting learning. Research-based instruction requires a great deal of interaction between environment, content, materials, teacher and learner (Orlich, Harder, Callahan and Gibson, 1998). The most important part of this method is that it gives both teacher and learner the opportunity to question, to express their opinions and to find solutions. Furthermore, it has some positive results like the students' being active, having improved understanding, and developed skills to understand the nature of science better (Metz, 2004; Wallace, Tsoi, Calkin and Darley, 2004). A teaching approache which provides a concrete learning environment in science courses, and enables students to take part in an active learning environment is a project-based learning (PBL) approach (Zacharias and Barton, 2004).

The basis of PBL is related to the idea of the progressivism in the beginning of the 20th century. The reconstructive approach by John Dewey, the project method of Klipatrick and the discovery learning approach by Bruner are the fundamentals of project-based learning. The aim of this learning method is to enable students to learn the subjects in an integrated way (Hamurcu, 2003). On the whole, PBL is defined as the students' study efforts for a certain period of time to reach a specific goal or result either individually or in a group through an active participation. The main aim of PBL is to help students take responsibility for their own learning and encourage them to work with others collaboratively (Cole, Means, Simkins and Tavali, 2002; Saban, 2000). PBL is a good method for those students who do not like just sitting and listening to lessons and it improves the critical thinking and idea synthesis abilities of the students. The projects must be related to real life situations and students must understand what they are learning and why they are learning these. At the end of each lesson, teachers should explain alternative uses of the information, skills, attitudes and behaviors in the projects (Titiz, 2001). In the project-based method, learning means that the learners are reconstructing their intellectual knowledge. Students can build their own knowledge by having real life experiences. On the other hand, they can be autonomous during the process and can make decisions by themselves. Such a situation improves their motivation, strategic motivation and prediction skills. This learning method also attracts the unwilling students and creates a learning environment where students with different abilities can create a more homogenous group (Solomon, 2003).

In recent years, there has been an increase in the number of researches studying PBL approaches in learning environments. In the studies related to PBL, it has been concluded that this approach has contributed positively to students' academic achievement (Cengizhan, 2007; Kanter and Konstantopoulos, 2010 ; Selçuk, 2010; Shih, Chuang and Hwang , 2010), to meaningful learning in science courses (Kanter, 2010; Krajcik, McNeill, and Reiser, 2008), to students' individual learning (Chang and Tseng, 2011), to their attitude towards science courses (Tortop and Özek, 2013), and to their academic personality (Korkmaz and Kaptan, 2002). Additionally, Hung, Hwang and Huang (2012) revealed in their study that technology-aided PBL was effective in enhancing students' motivation in learning science, their capability in problem solving and their learning achievement. Contrary to this, some studies claimed that this approach has no significant effect on the improvement of students' academic achievement (Ayan, 2012; Tabuk and Özdemir, 2009; Chang and Tseng, 2011).

Self-efficacy is an important concept in Social Learning Theory of Bandura (Bandura, 1995). It is the

personal judgment of the individuals about what to do and how much they can do to cope with possible problems (Hazır Bıkmaz, 2004). According to Bandura (1995), self-efficacy beliefs are the goals individuals decide on for themselves and these beliefs affect the decisions of the individuals on how much effort they should spend to reach their personal goals, how long they can cope with the problems that they will face and how they will react to any failure. In the last twenty years, self-efficacy beliefs have become one of the important topics in many studies of researchers who have conducted studies on teacher training. Studies on the self-efficacy beliefs of the teachers and prospective teachers in a specific field (science, math, etc.) provide an opportunity to understand the phenomenon of teacher training better (Hazır Bıkmaz, 2004). It has been pointed out in the studies that there is a relationship between the self-efficacy beliefs of teachers and their students' achievement (Allinder, 1995; Ross, 1994) and that teachers who have high levels of self-efficacy are more eager to implement methods that will lead their students to higher achievement and that these teachers are decisive and show quite a high level of performance (Sparks, 1998).

Primary school teachers are distinct fromother teachers in terms of their training programs due to being responsible for several disciplines as part of their professional life. As a result, primary school teachers should have competencies in understanding several disciplines as well as inter-disciplinary topics (Kahramanoğlu & Ay, 2013). One of these branches is science and technology teaching. Primary school teachers generally have some difficulties in teaching science and technology in Turkey (Huyugüzel Cavas & Kesercioglu, 2008). Science and technology teaching courses are important in primary school teacher training courses. This study examined the following research questions.

Research Questions

The study was guided by three research questions:

(1) *Are there statistically meaningful differences between students in a treatment group who were instructed with PBL method and students in a control group who were instructed through a traditional teaching (TT) method on post- SEBS scores?*
(2) *Are there statistically meaningful differences between students in a treatment group who were instructed with a PBL method and students in a control group who were instructed through a traditional teaching (TT) method on post-STTAT?*
(3) *(3) What are the opinions of students on the use of the project-based method in a science and technology teaching course?*

METHODOLGY

In this study, the pretest/posttest quasi-experimental method with a control group was used. There was one control group and one treatment group (Neuman, 2007). Quasi-experimental designs help researchers test for causal relationships in a variety of situations where the classical design is difficult or inappropriate.

Population and Sampling

The sample of this study consisted of 66 preservice primary school undergraduates in two classes who were selected from a population of 265 undergraduate students in seven classes in the Primary School Education Department of a State University in TURKEY. Both of the classes were taught by the same instructor. One of the classes was randomly chosen as the treatment group (n =33) which was instructed in a PBL method and the other class was also randomly chosen as the control group (n = 33), which was instructed on the same topic through the use of a traditional teaching (TT) method.

Data Collection Tools

The Science and Technology Teaching Achievement Test (STTAT): The test was developed by researchers and consisted of 28 multiple-choice questions that involved all the subjects in the science and technology teaching course. The questions were about Jean Piaget's learning theory, Jerome Bruner's discovery learning, Robert Gagne's learning theory, David Ausubel's learning theory, the theory of multiple intelligences, constructivist theory and the 5-E model. The questions on the test were reviewed by two science education experts and one expert in the field of measurement and evaluation. Necessary edits were made on the questions and the answer choices based on the recommendations of the experts. Six questions were omitted from the test as they were not found to be suitable in a reliability assessment. The reliability coefficient of the final 22 items in the test was 0,746 0.746. This test was administered as a post-test after the instruction.

The Self-Efficacy Belief Scale (SEBS): The scale was developed by Riggs and Enochs (1990). It was translated into Turkish by Hazır Bıkmaz (2004). The scale consisted of 20 items that could be answered on a 5- point Likert-type scale. The reliability of scale was found to be 0, 71. The scale was used both as a pre-test and post-test measure.

Interview Form

In order to solicit the opinions of the students on the method used, an interview form composed of open-ended questions was developed by the authors. While developing the form, literature survey on the field was done and the opinions of two science education experts were obtained. Interviews using the interview form were held with 10 students in the treatment group who volunteered to participate.

Treatment

The treatment and control groups had classes for three hours a week, with a total of 27 hours over 9 weeks. The topics covered during the instruction were as follows: Jean Piaget and learning theory, Jerome Bruner and discovery learning, Robert Gagne and learning theory, David Ausebel and learning, multiple intelligences theory, constructivist theory, and the 5-E model.

Before instruction, students in the treatment group were briefed about project based learning and were told what to do at each stage. The instruction in the project-based learning method was done as follows:

Determining the topic and subtopics and organizing the groups. There were 6 groups in the treatment group. Three of the groups included 5 students and the other three groups included 6 students in them. The students themselves decided on the name of their group. The students were told about the topics and subtopics.

Formulation of Group Project Plans: A timetable was made for each group and the date of each group was decided. During a three-hour lesson, the researcher introduced the topic to the students a week earlier and the students were told to organise study projects on the topics of the project concerned. In the following week, one group of students made their presentation, but all the groups submitted project reports to the teacher. The groups were given time to decide on who will give the presentation in the group

***Applying the project*:** The groups were required to plan their projects on the topics in the science and technology courses as taught at the fourth and the fifth grade. The resources that they would be able to utilize and the format of the project were explained to the students. During the process of carrying out the projects, the students were encouraged to talk to the researcher to get feedback.

Planning the presentation: The groups were advised to plan their presentation using the following headings: introduction, methodology, findings, discussion and comments, conclusion and suggestions.

Presentation: The groups presented their projects with their goals to the other class members.

Evaluation: The groups were given feedback by the researcher and other students and asked questions.

The implementation of the traditional teaching method was as follows: In the control group, the learning theories mentioned above were explained to the students by the researchers and students were given examples of the use of the relevant theories. During the course, the theories with their different features were introduced, the ways of applying these theories and the activities related to the use of the theories were explained to the students. These activities were were conducted on the topics and objectives of the 4th and the 5th grade science and technology courses. After the activities, the students were asked questions and were required to generate examples.

Data Analysis

The data obtained from the subjects were entered into an EXCEL datasheet and in order to determine effects of the project-based method on students' academic achievement and self-efficacy beliefs, an analysis of covariance (ANCOVA) was performed on the data to test the first research question, while an independent t-test was performed to answer the second research question.

For the analysis of the qualitative data, the structured interview form was used with 10 students who volunteered from the treatment group. Then, the recordings were transcribed and were subjected to a content analysis and categorized. The interviews were recorded and then analyzed by two separate researchers. The Miles and Huberman (1994) reliability formula.

(Reliability = Consensus / (Consensus + Dissidence), was used in the analysis.

According to this formula the reliability was found to be 90%. If the reliability was greater than 70% the data were considered reliable (Yıldırım & Şimşek, 2005). Hence, the results obtained from the study can be said to be reliable. While reporting the interviews, the content of the questions was explained and the categories of all questions were presented and quotations from the interviews were given.

RESULTS

Based on the data obtained by the Self- Efficacy Belief Scale (SEBS), the students' mean and standard deviations for the pretest and posttest scores for the treatment and the control groups were calculated and displayed in Table 1.

It is seen from the table that students' mean scores in the pre-SEBS and post-SEBS were similar for the treatment and the control groups. Prior to the treatment, an independent t-test was employed to determine whether there was a statistically significant

Table 1. The mean and standard deviation for pre-SEBS and post-SEBS

Groups	Dependent Variables	n	Mean	Standard Deviation
Project-based	Pre- SEBS	33	70,757	7,504
Learning	Post- SEBS	33	72,969	9,040
Traditional Method	Pre- SEBS	33	67,757	7,504
	Post- SEBS	33	65,757	7,927

Table 2. Summary of ANCOVA Comparing the Mean Post-SEBS Scores of Students in Treatment and Control Groups

Source Dependent Variable		df	Means Square	F	P	Partial Eta Square
Pre- SEBS	Post- SEBS	1, 63	1116,35	19,808	0,000*	0,239
Group	Post- SEBS	1, 63	485,14	8,608	0,005*	0,120

*n=66, *p<0,05*

Table 3. The Comparison of the Results Obtained in the post-STTAT

Variable	X	SD	t	df	P
Post-STTAT					
Group 1(PBL)	16,969	3,44			
Group 2 (TT)			2,08	64	0,042*
	15,091	3,88			

*n= 66; *P< 0,05*

mean difference between the control and treatment groups with respect to the pre-SEBS scores. The analysis of results showed that there was no significant mean difference in the pre-SEBS scores between the groups [(t (65) = 1,602, p > 0,05)]. Beside this, it was observed that there was a statistically significant relationship between the scores obtained by the students in pre-and post-SEBS (r (67) = 0,519, p<0, 01). Due to the significant relationship between the pre- and post-tests and in order to remove the effect of pre-SEBS scores on the post-SEBS scores, the pre- SEBS was used as a covariate.

After the treatment, the analysis of covariance (ANCOVA) was run to compare the effects of instruction on students' post-SEBS scores. Levene's Test was used to check the assumption that error variance of the dependent variable is equal across the experimental and control groups. The significance value for the dependent variable, post-SEBS scores, (F (1, 65) =0.003; p>0.05) was greater than 0.05, meaning that the equality of variances assumption was not violated. Table 2 contains summarises the ANCOVA results comparing the mean scores of students' performance in both the treatment and the control group with respect to the post-SEBS scores.

As seen in Table 2, the students in the treatment group who were instructed in the project based learning method obtained higher post-SEBS scores than the control group students who were instructed through a use of the traditional method [F (1.63)= 8,608, p<0.05. η = 0.129].

An independent t-test analysis was used to see if there was a statistically significant mean difference in the scores obtained by students in the post-STTAT; the results are summarised in Table 3.

It is seen from the tables that the students in the treatment group who were instructed through the project based learning method demonstrated better performance measured by post-STTAT scores as compared to the control group students who were instructed by using the traditional method [t (64)=2,08. p<0.05].

Qualitative Findings

The findings of the document analysis are summarised in Table 4.

As seen in Table 4, the students expressed positive opinions about the use of the project-based learning method involving cooperative and systematic work, getting to know the chapters and subjects of the 4th and 5th year courses and working independently. Although there were negative opinions about the effects of the project-based learning method on the efficiency of teaching science as well as the groups' being at different levels and working independently, the opinions of the students on the other categories were positive. However, the students mentioned that they had problems with getting used to the method, the lack of time and the structure of the groups.

Table 4. The Opinions of the Students from the Primary Education Department on the Use of Project-Based Learning in the Science and Technology Teaching

The content of the question	Categories	Quotations
The effect of project-based learning on Science and technology teaching	*Positive* Learning process Science teaching The application of learning theories Permanence of learning Learning by experiencing Learning level Material use in science teaching	*"We did activities on the topics. The presentations and explanations were very effective in teaching and learning of science subjects and they enabled us to develop our abilities at the high levels."* *"It was very good for our understand science teaching experiences."*
The effects of project-based learning on the efficiency of science teaching.	*Positive* The feeling of fear and nervousness- about science Interesting and enjoyable teaching and learning Why, what and how to do Methods and techniques Preparing activities *Negative* Anxiety	*"I used to answer 'No, I cannot' when I was asked whether I could teach science…. During the science education depending on project-based learning method, I had a chance to get acquainted with the approaches and this helped me to improve myself…..from now on I know how to lecture in accordance with constructivist and multiple intelligence theories."*
Difficulties faced by students during the science and technology teaching course	Not being able to get used to the new method Lack of time The structure of the groups Deficiencies in science and technology Students from social sciences Internet Information pollution Reporting	*"We utilized from the Internet. Therefore, there was information pollution and we had difficulty in the analysis."* *"The sample activities limited us while we were preparing activities…..".*
The effects of project-based learning in science and technology teaching on the students' cooperative and systematic studies.	*Positive* Work share Participating in group work Information exchange and share Producing a product cooperatively Interactive learning environment Planned working and reaching to a result	*"While doing research, we shared information……."* *" ……during the preparation of the project, we had work-share; we collected data and shared them."*
The effect of project-based learning on helping the students to get acquainted with the units and topics of science and technology teaching course in the 4th and 5th class.	*Positive* The content and limits of the topics Relation between the topics Scientific content of the topics	*"… we are able to know which unit contains which topics and we also knew their content."* *"….we can have knowledge about the advanced information on the topics and know the relation between the topics."*
The effects of different group levels on the course	*Positive* Positive contribution To be able to develop activities *Negative* Work-share Understand	*"Our classmates from the field of science have better knowledge than us….we were less interested in the course as we did not like it."* *"Differences within the group contributed to the project and the contributions of the friends led to a better project."*
The effects of project-based learning method on the students' ability to work independently	*Positive* Individual responsibility Data collection, presentation and literature survey Developing activities Designing material Sense of mission Using computers in education *Negative* Being reluctant in individual work	*"I was able to improve effective use of computer and I used it in material design".* *"… I tried to make the lesson more effective with the activities I did individually."*

DISCUSSION AND RECOMENDATION

The main purpose of this study is to compare the effect of a project based learning and a traditional instruction on undergraduate students' achievement in the Science and Technology Teaching Course and their Self-Efficiency Beliefs. Also the students' opinions about the Project Based Learning Methods in the treatment group were investigated. The main difference between the two teaching methods was that the students in the treatment group followed the schedule based on the Project Based Learning while the ones in the control group received the same information through a traditional teaching method.

According to the findings of the data obtained for research question 1 of this study it was found that when the Project Based Learning Method was used, the undergraduate students' self-efficiency beliefs about the science learning and teaching have increased more as compared to when the traditional method was used. Ashton (1984) described the self-efficacy beliefs of the teachers as having an impact on the students' performance and also mentioned that none of the other teacher characteristics could be consistent with the students' achievement as much. Becoming aware of one's own beliefs about teaching and learning about a class activity is important (Al-Amous, Markic, Abu-Hola and Eiks, 2011). The students' active participation in the projects provides the students with opportunities for shaping their thoughts and allow them to put forward their own points of view (Zoller, 1990); students also have the opportunity to do activities which interest them. The students were able to increase their self-efficacy beliefs by doing projects on the courses of science teaching. The prospective teachers who presented their projects in front of the classroom and who tried to create an effective product with the help of feedbacks went through an experience during which they got acquainted with the topics of science and reached a stage at which they were able to confidently use the teaching and learning approaches. The studies that are reported in the literature done on the time-use and classroom management techniques and methods (Gibson and Dembo, 1984; Saklofske, Michayluk and Randhawa, 1998; Woolfolk, Rosoff and Hoy, 1990) support the finding that they have relationships with the self-efficacy beliefs of teachers.

According to the findings from the data for research question 2 in this study, it was found that when the Project Based Learning Method was used, undergraduate students' achievement in The Science and Technology Teaching Course have increased more as compared to that of the students who were instructed by using the traditional method. This result is consistent with the results presented in the literature which show that the project-based learning method had positive effects on undergraduate students' achievement (Dağ and Duru, 2011; Gültekin, 1992; Özcan, 2007). One of the most important outcomes in science education is to increase students' interaction with the teaching and learning process. In such an environment, it is the teachers who take on important missions and who provide an interactive environment (Fidan, 1996). It is inevitable that the experience and knowledge of teachers in science education will be reflected on their students. The project-based method encourages students to be involved through an active participation in a mental and physical activity that requires in-depth research; it is a method which takes into account the product and the output by students to show that they have understood the topics of the lesson and also the process (Toprak, 2007). According to Solomon (2003), the evaluation in the project-based learning should be authentic. For instance, students may be required to submit written assignments, do observations, presentations and be involved in discussions. The self-evaluation tools (rubrics) can be helpful at the beginning to tell students what is expected from them. During the projects, the process could be taken into consideration more for the evaluation.

According to the findings from the qualitative data, it can be observed that students gave positive opinions about the method used. Looking at the positive opinions given for the categories such as "the application of the theories, learning level, the use of material in science teaching, etc.", we can see that they mentioned their achievement in classes. The opinions of the students on the categories such as fear and nervousness about science, interesting and enjoyable teaching, method and techniques, supported the findings obtained for the second sub-problem of the study. In the experiment process the students were asked at what stages they had difficulty. By answering with the following quote, they drew attention to the problems which had to be overcome:

"…we utilized information from the Internet during the research. Therefore, there was information pollution and we had difficulty in analysing (this information)",.

From the answers of the students to the questions about the effect of the method on working cooperatively and systematically, it can be seen that even though the students had difficulty in getting used to the method, it had a positive effect on their group work. Besides, the students mentioned that they gained competence in teaching the 4th and 5th year topics of the science and technology teaching courses and that they determined the outlines of the topics in the first stage of the primary education. According to Dağ and Durdu (2011) project based learning contributed to student learning by doing and living and affected their course success positively. Building projects for all students studying in higher education, ensuring the active participation in their

learning process must often be implemented in order to establish a sustained learning process are among the proposals of researchers (Demir, 2013). The results of the present study are also parallelling the results of some previous studies (Gultekin, 2005; Meyer, Tuncer, and Sperncer, 1997; Penuel and Means, 1999). In conclusion, when teaching materials which are prepared based on the project-based learning method are used in a learning environment, undergraduate students develop better performance skills in science and technology teaching and have more increased self-efficiency beliefs as compared with students instructed by using the traditional method.

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