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A COMPARATIVE ANALYSIS OF PROBLEM-BASED LEARNING APPLICATIONS İN ENGINEERING AND TEACHER EDUCATION: A BRIEF REVIEW

MÜHENDISLIK ve ÖĞRETMEN EĞİTİMİNDE KULLANILAN PROBLEME DAYALI ÖĞRENME UYGULAMALARININ KARŞILAŞTIRMALI ANALİZİ: KISA BİR LİTERATÜR TARAMASI

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Abstract

Problem-based learning (PBL) is an alternative instructional method used to help students acquire scientific and technical knowledge. It has various uses in different disciplines ranging from language learning to nursing. Considering the effectiveness and common usage of problem-based learning, this study is a brief literature review that focused on the use of PBL in two different disciplines, namely, in engineering and teacher training. To this end, the researcher chose 4 articles that are among the most cited studies on Google scholar's web page. The review was conducted to identify the research areas such as scope, research questions, methodologies, common emergent features and overall implications of those studies. As for analysis, coding and categorizing the themes were done in all studies to find common aspects. The emergent themes were discussed, and implications were examined successively. The results showed that applications and utilization of PBL in engineering and teacher training were proven to be beneficial both for the educators and the students of the target area. The study also demonstrated that while analytic thinking, quick decision making, and synthesizing were the primary targets of the use of PBL in engineering, collaboration and comprehension skills are targeted by the practice of PBL in teacher training.

Keywords: Problem-based learning, engineering, teacher training, teaching method

Özet

Probleme dayalı öğrenme, öğrencilerin bilimsel ve teknik bilgi edinmelerine yardımcı olmak için kullanılan alternatif bir öğretim yöntemidir. Dil öğreniminden hemşireliğe kadar farklı disiplinlerde çeşitli kullanımları vardır. Probleme dayalı öğrenmenin etkinliği ve yaygın kullanımı göz önüne alındığında, bu çalışma probleme dayalı öğrenmenin mühendislikte ve öğretmen eğitiminde kullanımına odaklanan kısa bir literatür taramasıdır. Bu amaçla araştırmacı, probleme dayalı öğrenme kullanılarak gerçekleştirilen ve Google akademik internet sayfasında en çok atıf alan araştırmalardan 4 tanesini seçmiştir. Bu araştırma, odaklanılan çalışmaların kapsam, araştırma soruları, metodolojileri, ortaya çıkan özellikler ve bu çalışmaların genel etkileri gibi araştırma alanlarını belirlemek için yapılmıştır. Analizde kısmında tüm çalışmalardaki ortak yönleri bulmak için temaların kodlanmış ve kategorilere ayrılmıştır. Analiz sonucunda ortaya çıkan temalar tartışılmış ve çıkarımlar sırasıyla incelenmiştir. Sonuçlar, mühendislik ve öğretmen eğitiminde probleme dayalı öğrenme kullanımının hem eğitimciler hem de hedef alandaki öğrenciler için faydalı olduğunu

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kanıtlamıştır. Çalışma ayrıca, mühendislikte probleme dayalı öğrenme kullanımının ana hedeflerinin analitik düşünme, hızlı karar verme ve sentezleme olurken, öğretmen eğitiminde ise işbirliği ve anlama becerilerinin hedeflendiğini göstermiştir.

Anahtar Kelimeler: Probleme dayalı öğrenme, mühendislik, öğretmen eğitimi, öğretme yöntemi

1.INTRODUCTION

Problem-based learning is a popular approach to education that focuses on creativity, critical thinking and social learning. It is a student center method that gives independence and creative learning opportunities to students. Margetson (1994) stated that using problem-based learning (PBL) in Higher Education surroundings across a range of industrialized nations has increased during the last 10–15 years in response to changes in the global economy and work patterns. As the universities demand various characteristics from their students, such as critical thinking, problem-solving and the ability to work in collaboration and cooperation, the use of problem-based learning has increased gradually. The application of problem-based learning in universities can potentially create the working force of the 21st Century who have mastered these skills and use them for further investigation in education, art, science and academics.

Problem-based learning has some principles to follow for the applicants. As Yong (2005) suggested, the most important part of PBL is an appropriate problem that comes from the real world and has a relationship with the course. These real-life problems are used as a means of stimulating student's interest and encourage activity. This problem should be given to a group of students who are going to study and work in cooperation and collaboration to solve it. The teachers of PBL assign students into groups and give them homework to research a question. For PBL to work properly, the questions must be complex enough so that there is no one right answer', but rather a group of potential answers and strategies to enhance interdependence and communication (King, 2005). It is clear from King's statement that multiple realities and answers play an essential role in applying problem-based learning. According to Yong (2005), PBL offers students an obvious answer to the questions, 'Why do we need to learn this?' and 'What does what I am doing in school have to do with anything in the real world?' Finding answers to these questions in a group develops different students' skills, including critical thinking, reflective thinking, communication, and collaboration. Yong (2005) stated another essential characteristic of the PBL is that it promotes metacognition and self-regulated learning by asking students to generate their own strategies for problem definition, information gathering, data-analysis, hypothesis-building, and testing. It is evident that having competence in PBL techniques has many advantages for the learners.

As a result of the implementation and common use of problem-based learning, this study aimed to find out the most popular studies in the relevant literature that focused on the use of problem-based learning in engineering and teacher training areas. In addition, this study also aimed to find out the differences and similarities between the uses of PBL in engineering and teacher training departments.

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2. METHODOLOGY

As a broad field, problem-based learning was selected as the target issue for this brief literature review to reach the most popular studies. The studies were chosen considering the popularity of the articles by searching them on the google scholar webpage. The researcher selected 4 studies that have the most citations in using PBL in engineering and teacher training. As for analysis, coding and categorizing the themes were done in all studies to find common aspects. The emergent themes were discussed, and implications were examined successively.

3. FINDINGS

The researcher selected 4 studies in the area of using problem-based learning in engineering and teacher training. The names of the studies, the researchers, their focus areas, data collection tools, design and effect of the implementation of PBL were given in Table 1 below.

Table 1. Descriptive Details of PBL Studies

Name of The Study	Researcher(s)	Focus Area	Data Collection Tools	Design	Effect
Using problem-based learning in the Electrical Engineering Foundation	Lei Yong, 2005	Engineering	Interviews	Case study	Partly Positive
Electrical engineering students evaluate problem-based learning (PBL)	Ribeiro, 2010	Engineering	Observations Questionnaire	Mixed method	Positive
Laura's story: Using Problem Based Learning in Early Childhood and Primary Teacher Education.	Edwards and Hammer, 2006	Teacher Training	Reflective essay Questionnaire	Mixed method	Positive
BL in Teacher Education: Its Effects on Achievement and Self-Regulation	Erdogan and Senemoglu, 2017	Teacher Training	Achievement test, Open-ended Exam, Questionnaire Interviews	Experimental	Positive

As it is evident from Table 1, four distinctive articles were analyzed and summarized to compare the implementation of problem-based learning on engineering and teacher education. The title of the first article is 'Using problem-based learning in the Electrical Engineering Foundation,' and it was conducted by Yong (2005). It is a case study that focused on the use and advantages of using problem-based learning in the electrical engineering department. The article deals with the use and application of problem-based learning for students. The researcher tried to implement PBL techniques in an electrical engineering course for non-electrical engineering students. The researchers modified the course to implement PBL techniques during the lectures. As well as behaviorist strategies, the researcher used constructivist strategies, developmental strategies, and concept mapping. To collect the

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intended data, the researcher created three real-world problems, which include most of the content of the course.

To solve the problems and to guide the students, the researcher gave lectures about the problem areas. During the lectures, the fundamental concepts and values of diagnostic methods were discussed but not all ideas and techniques. To give students enough time for self-learning, and conversation, the teacher-researcher assigned less homework than before. Then, the researcher provided tutorials for the students. Although group work is encouraged in the tutorials, students could ensure that they can solve them individually. Also, the researcher helped the students at the laboratory. Laboratory work formed an integral part of the lesson. It allows students to connect the theoretical knowledge with project practices. Finally, the researchers gave seminars to the students about their target areas. Students would share the information they had found during the seminar section, discuss the problem, and exchange their ideas. The researcher collected the intended data via student interviews.

The results of the study demonstrated that the effect of PBL on students' learning is not high. As the course electrical engineering foundation is not within the students' primary area of specialization, the students have little attention in the class and approach the learning experience passively. Therefore, the influence of teaching is not as practical as it has to be. Nevertheless, it is proven that PBL is an appropriate way of information transmission for non-electrical engineering students. Moreover, PBL was proven to increase student interest and involvement in the lectures.

The title of the second article is 'Electrical engineering students evaluate problem-based learning (PBL)', and it was conducted by Ribeiro (2010). In this mixed-method study, PBL was implemented in an electrical engineering program at a public university in Brazil. The researcher used participant observation of classes and an end-of-term questionnaire as data collection tools. This study conducted in Brazil was implemented in the electrical engineering department. This research aimed to evaluate the operation of PBL in electrical engineering education. It also sought to discuss the students' perspectives as regards the pros and cons of using PBL. To find the intended results, the researcher used both quantitative and qualitative research methodology. In this research, PBL was implemented as an instructional method in an electrical engineering program at a public university in São Paulo, Brazil. The participants of the study were 38 students. The PBL format was based on the mentioned principles and process and suggestions. As it is typical for problem-based learning, the researcher introduced a problem for the students.

The results showed that PBL received a positive evaluation from students. Students stated that PBL creates a more dynamic and enjoyable learning environment. On the other hand, even though some students did not experience any disadvantages to PBL, others indicated that it increased their time/workload. Considering the duration of the study and changing roles of students and teachers, the heavy workload may be acceptable at a certain level. In short, despite a few disadvantages of the PBL, it is a valuable method for engineering students, and it fosters problem-solving, communication, teamwork, self-directed and life-long learning skills and attitudes as the participants report it.

The title of the third article is 'Laura's story: Using Problem Based Learning in Early Childhood and Primary Teacher Education, and it was conducted by Edwards and Hammer

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(2006). This study is conducted to show the influence of PBL on teacher training and teacher education. The study includes the perceptions of pre-service educators who participate in a study conducted using a PBL scenario. The data of the study was recorded by examining pre-service educators' responses to their participation in a PBL scenario. The pre-service educators participating in the unit of the study were 2nd, and 3rd-year bachelor degree students registered in early childhood education programs, and they have experience in the field. The PBL scenario necessitated the participants working in groups of five to find out the learning and developmental needs of Laura. Each member of the group haphazardly took up a different stakeholder role in Laura's life. As part of the unit homework, the participants developed a presentation about their understanding of Laura's development and her learning needs from their particular perspectives. As a final assignment, the pre-service educators completed a reflective essay in which they examined their interactions with the other stakeholders. Data of the study were collected using a questionnaire and reflective essays of the participants. While the data acquired via questionnaires were analyzed by using SPSS, the qualitative responses were coded in NVIVO and analyzed thematically.

The mean score findings suggested that the pre-service educators perceived participation in the scenario as serving them to relate theory to practice. In addition, the findings specified that participation in the PBL scenario reinforced their ability to identify likely issues they may experience as teachers. This process also improves the participants' sense of responsibility as a teacher.

The title of the fourth and the last article is 'PBL in Teacher Education: Its Effects on Achievement and Self-Regulation.' This study was conducted as experimental research by Erdogan and Senemoglu (2017). This experimental study aimed to find out the influence of PBL on teachers' academic achievements and self-regulation. The researcher collected both qualitative and quantitative data. An achievement test, an open-ended exam and a scale on self-regulation in learning were utilized as a means of quantitative data collection. On the other hand, student interviews were used as a qualitative data collection tool. While the number of students in the experimental group was 36, the number of students in the control group was 21. The researcher continued to the usual flow of the lessons with the control group, whereas the lessons in the treatment group were implemented according to the principles of PBL.

Results of the study revealed that both control and treatment groups performed similarly in their knowledge level achievements. However, the experimental group performed better than the control group in terms of comprehension and achievements. On the other hand, the findings obtained via the content analysis of student interviews went parallel with the quantitative findings. The interviews demonstrated that PBL has a positive influence on all levels of participant achievements. Students claimed that they learned more during PBL application as PBL helps them share the information among group members and improve their language knowledge. In conclusion, the study demonstrated that PBL continues to meaningfully influence all levels of education and across different disciplines.

DISCUSSION

After the detailed analysis of the articles that focus on PBL in engineering and teacher education, it can be stated that PBL is a very beneficial method both for teacher and engineering

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candidates. It is a student-centered approach in which students learn about a subject by working in groups to solve an open-ended problem. It encourages students to work together to find potential solutions to the problem by combining their resources by posing a very challenging problem.

The identification of the articles demonstrated that using PBL in electrical engineering is an advantageous method. As stated above, problem-based learning has many potential usages, and educators need to consider them helpful teaching aids for the students in engineering. Studies in the 1990s demonstrated that the engineering curricula and its graduates were generally deficient in addressing the concerns of modern society (Mills & Treagust, 2003). According to the researchers (Mills & Treagust, 2003; NAE, 2005), engineering graduates lack necessary skills and have difficulty applying their fundamental knowledge to practice problems in their target area. When they lack these qualities, it is not easy for the teachers to raise young engineers who are competent in engineering. It is clear from the studies that PBL has the potential to provide benefits for young engineers and solve their academic problems.

Another reason for the potential use of the PBL in engineering is the complaints of the engineering students. One criticism from engineering students is that the current teaching pedagogies emphasize clear instruction, working individually, and norm-referenced grading. This makes learning extrinsically motivating rather than intrinsically motivating (Felder et al., 1998). Considering the situation above, it is not surprising that engineering students who need active participation, problem-solving skills, and practice have difficulty in having enough of these characteristics from the lectures. To solve this problem, PBL might be adopted by engineering programs to help graduates learn the skills required by the engineering industry. When the students have finished the learning process, they can combine new knowledge with their existing cognitive framework and have formed satisfactory networks to make that new knowledge reachable thanks to PBL (Schmidt et al., 2011). It is evident that PBL helps engineering students in many ways and assists them in acquiring necessary skills expected from an engineer, such as organizing, problem-solving, better retention and critical thinking.

Teacher training and education are the other focus areas of problem-based learning. Using problem-based learning to train teachers is an advantageous method considering the potential benefits of PBL for novice teachers. It can be stated that to be a qualified teacher, one needs to actively construct his/her own cognition. In this respect, the philosophical foundations of PBL that depend on constructivist and social-constructivist views of learning help learners construct their cognition and comprehension. Therefore, it can be stated that PBL is a suitable method to increase teachers' productive capacities. Another reason to use PBL in teacher training is that the teacher candidates require particular skills related to their ability to practice and understand theoretical and content knowledge as an informant to their practice. It is evident that PBL helps teacher candidates close the gap between theory and practice. As a result, PBL can be an excellent assistant for them.

PBL is a useful method also for pre-service training of teacher candidates. As we all know, pre-service education is an essential part of the teacher training system. During this stage, the teacher candidates acquire valuable knowledge about their future practices and careers. For this reason, pre-service training should be considered vital, and the implementations ought to be planned carefully. To train teachers at this stage, using PBL can

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be a good solution. Some studies have found positive results concerning PBL's influence on developing self-regulation and motivational elements for the teacher candidates (Erdoğan and Senemoğlu 2017). Empirical studies of PBL reveal that teacher candidates trained with PBL can better apply their knowledge to different problems and use more effective self-directed learning strategies than other students (Dochy et al., 2003; Mamede, Schmidt, and Norman, 2006). It is evident that PBL has positive effects on teacher candidates' collaboration, problem-solving, self-regulation and inquiry skills. It can be inferred that PBL provides many constructive outcomes and can be used for teacher training.

CONCLUSION

The results showed that applications and utilization of PBL in engineering and teacher training were proven to be beneficial both for the educators and the students of the target area. This result of the study has some similarities with the one conducted by Yong (2005) that found out that using PBL in different disciplines provides distinctive benefits for the personal and academic careers of the students.

The results of the study also demonstrated that most of the methods, applications and utilization of PBL have similar characteristics in engineering and teacher training. One of the most important similarities is the use of a real-life problem to teach content. By providing a challenging problem for the learners, the educators want to increase collaboration, cooperation, and communication. This harmony helps learners feel as if a part of a family and increases their productivity. The acquisition of 21st Century skills such as critical thinking and the ability to have good comprehension is also the target of both disciplines that use PBL in the center of their education systems. This finding of the study is supported by the research conducted by De Graaf and Kolmos (2003) that revealed that PBL increases collaboration, communication, cooperation, self-regulation and critical/creative thinking skills of the students.

It is also proven in this study that despite sharing some standard features, engineering and teacher education departments implementing PBL in their education systems have some differences. The first one is in the acquisition of the target skill. While analytic thinking, quick decision making, and synthesizing were the primary targets of the use of PBL in engineering, collaboration and comprehension skills are targeted by the practice of PBL in teacher training. Also, the studies conducted in engineering are longitudinal studies taking a few years before the analysis phase. However, the studies about implementing PBL in teacher training takes a shorter time and include the submission and education of the trainees. This finding of the study goes parallel with the one conducted by Kolmos and Graaf (2014) that showed that the implementation of problem-based learning could take up various roles and missions in different academic disciplines.

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REFERENCES

de Camargo Ribeiro, L. R. (2008). Electrical engineering students evaluate problem-based learning (PBL). *International Journal of Electrical Engineering Education*, *45*(2), 152 161.

De Graaf, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *International Journal of Engineering Education, 19*(5), 657-662.

Dochy, F., M. Segers, P. V. Bossche, and D. Gijbels. 2003. "Effects of Problem-Based Learning: A Meta-Analysis." Learning and Instruction 13 (5): 533–568.

Edwards, S., & Hammer, M. (2006). Laura's story: Using problem-based learning in early childhood and primary teacher education. *Teaching and teacher education*, *22*(4), 465 477.

Erdogan, T., & Senemoglu, N. (2017). PBL in teacher education: its effects on achievement and self-regulation. *Higher Education Research & Development*, *36*(6), 1152-1165.

Felder, R. M., Felder, G. N., & Dietz, E. J. (1998). A longitudinal study of engineering studentperformance and retention V. Comparisons with traditionally-taught students. *Journal of Engineering Education, 87*(4), 469–480.

King, M. (2005) Lecture notes: *Teach Science in English.* The University of Sydney.

Kolmos, A., & de Graaff, E. (2014). Problem-based and project-based learning in engineering education. *Cambridge handbook of engineering education research, 1,* 141-161.

Mamede, S., H. G. Schmidt, and G. R. Norman. 2006. "Innovations in Problem-Based Learning: What Can We Learn from Recent Studies?" Advances in Health Education 11: 403–422.

Margetson, D. (1994). Current educational reform and the significance of problem-based learning. *Studies in higher education, 19*(1), 5-19.

Mills, J. E., & Treagust, D. F. (2003). Engineering education — Is problem-based or projectbased learning the answer? *Australasian Journal of Engineering Education*, 2 16.

National Academy of Engineering (NAE). (2005). *Educating the engineer of 2020: Adapting engineering education to the new Century*. Washington, DC: The National Academies Press.

Schmidt, H. G., and J. H. C. Moust. 2000. "Factors Affecting Small-Group Tutorial Learning: A Review of Research." In Problem-Based Learning: A Research Perspective on Learning Interactions, edited by D. H. Evensen and C. E. Hmelo, 19–52. Mahwah, NJ: Lawrence Erlbaum.

Yong, L. (2005). Using problem-based learning in electrical engineering foundation. *The China Papers*, *5*, 67-70.