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Comparative Analysis of Problem-Based Learning and Traditional Instruction Methods in Postgraduate Studies: A Synthesis of Effects on Learning Outcomes

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Probleme Dayalı Öğrenme ve Geleneksel Öğretim Yöntemlerinin Lisansüstü Çalışmalarda Karşılaştırmalı Çözümlemesi: Öğrenme Çıktıları Üzerine Etkilerinin Sentezi

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Abstract

This research aimed to evaluate and synthesize the effectiveness of problem-based learning (PBL) compared to traditional instruction (TI) in various learning outcomes. The study, using a sequential explanatory mixed research approach, reviewed 74 postgraduate dissertations from Türkiye, spanning from 2009 to 2021, that matched specific inclusion criteria. Qualitative data analysis revealed that the majority of these dissertations were master's level and completed in 2010. These studies frequently implemented experimental interventions in middle school science classes, typically over five weeks with groups of 21-30 students. The quantitative analysis showed that PBL had a significant overall impact, with a General Effect Size (GES) of 0.734 across all variables. This effect was divided into specific clusters: knowledge (GES of 0.992), skills (GES of 0.696), and emotions (GES of 0.406). Further, PBL particularly affected academic achievement (GES of 0.842), scientific process skills (GES of 0.351), and course attitude (GES of 0.402), which were the most commonly assessed variables in the respective dimensions of knowledge, skills, and emotions. Additionally, PBL showed a substantial impact (GES of 0.799) on variables covering 21st-century competency framework skills. In summary, the study found that PBL is significantly more effective than traditional instructional methods across various learning outcomes, particularly in enhancing knowledge, skills, and emotional aspects of learning. This study suggests that integrating PBL activities can significantly enhance the attainment of curriculum objectives.

Article Info

Keywords: Problem-based learning, traditional instruction, meta-evaluation, learning outcomes

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Öz

Bu araştırma, problem dayalı öğrenmenin (PDÖ) geleneksel öğretim yöntemleriyle (GÖ) karşılaştırarak çeşitli öğrenme çıktıları üzerindeki etkilerini değerlendirmeyi ve sentezlemeyi amaçlamıştır. Sıralı açıklayıcı karma araştırma yaklaşımı kullanılan araştırmada, 2009'dan 2021'e kadar Türkiye'den belirli dahil etme kriterlerini karşılayan 74 lisansüstü tezi incelemiştir. Nitel veri analizi, önemli sayıda lisansüstü çalışmanın özellikle 2010 yılında tamamlandığını ve büyük oranda yüksek lisans tezlerinden oluştuğunu ortaya koymuştur. Bu çalışmalar genellikle deneysel müdahaleler olarak ortaokul fen derslerinde, beş hafta süreyle ve 21-30 öğrencilik gruplarla, yürütülmüştür. Nicel analiz, PDÖ'nün tüm değişkenler üzerinde anlamlı bir genel etkiye sahip olduğunu, Genel Etki Büyüklüğü'nün (GES) 0.734 olduğunu göstermiştir. Bu etki, belirli kümeler olarak ayrılmıştır: bilgi (GES 0.992), beceriler (GES 0.696) ve duygular (GES 0.406). Ayrıca, PBL özellikle akademik başarıyı (GES 0.842), bilimsel süreç becerilerini (GES 0.351) ve ders tutumunu (GES 0.402) etkilemiştir ki, bunlar sırasıyla bilgi, beceriler ve duygular boyutlarında en sık değerlendirilen değişkenlerdir. Ek olarak, PBL, 21. yüzyıl yetkinlik çerçeve becerilerini kapsayan değişkenlerde önemli bir etki göstermiştir (GES 0.799). Sonuç olarak, çalışma, PDÖ'nün çeşitli öğrenme kazanımları, özellikle de öğrenmenin bilgi, beceri ve duygusal yönlerini geliştirmede, açısından geleneksel öğretim yöntemlerinden anlamlı olarak daha etkili olduğunu ortaya çıkarmıştır. Araştırmada, PDÖ etkinliklerinin, müfredata entegre edilmesinin, müfredattaki hedeflere ulaşmayı önemli ölçüde artıracağı ileri sürülmektedir.

Makale Bilgisi

Anahtar Kelimeler: Probleme dayalı öğrenme, geleneksel öğretim, meta değerlendirme, öğrenme çıktıları

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Introduction

Individuals acquire the knowledge, skills, and attitudes essential for life through teaching methodologies grounded in solid theoretical foundations and empirical research findings (Eggen & Kauchak, 2016). Learning and teaching processes, as posited by behavioral, cognitive, and information processing theories, involve changes in behavior, the renewal of meaning schemas, and the consolidation of information into long-term memory (Schunk, 2012). The shift from behavioral theories to constructivist theories sparks a critical reevaluation of traditional instructional (TI) methods, encouraging the development of constructivist teaching methodologies focused on supporting the ability to generate and utilize knowledge (Ormrod, 2016). These constructivist teaching methodologies provide more engaging, learner-focused educational encounters. In these settings, students proactively build their own comprehension and awareness of the world by engaging with and reflecting on their experiences. This paradigm shift emphasizes the importance of a learner's engagement in constructing knowledge, as opposed to passively receiving it. Consequently, it necessitates the design of learning environments that are dynamic, interactive, and rich in resources, thereby enabling learners to question, explore, and challenge their understanding. As a result, this supports more profound and durable learning, equipping individuals with the vital skills and competencies necessary for lifelong learning and adaptability in an ever-changing world.

According to the constructivist learning theory, when a person cannot explain new information within the framework of his prior knowledge and experiences, they reorganize mental meaning schemas at the end of cognitive inquiry processes (Pelech & Pieper, 2010). In line with constructivist teaching methods (Borich, 2017) that provide opportunities for learners to evaluate and develop their prior knowledge and experiences, schools should create free-thinking environments for students and teachers should assume a guiding role (Woolfolk, 2016). Problem-based learning (PBL) is a method based on constructivist learning principles, working with real-life problems, in which students take responsibility, and adopt collaborative working and reflective thinking processes (McConnell et al., 2016). PBL aims to provide students with the competency to solve problems they may encounter in society and work life, take advantage of opportunities, protect themselves from threats, and adapt to changing conditions (Moust et al., 2019).

In the PBL process, teachers present problems in line with real life within scenarios and enable students to reach a solution by applying the steps of the scientific method (Amador et al., 2006). Students taking responsibility, integrating knowledge and experience from different disciplines, and collaborating with their peers contribute to their acquisition of lifelong learning understanding (Bidokht & Assareh, 2011; Eggen & Kauchak, 2012; Uden & Beaumont, 2006). The philosophical foundations of the PBL method are based on John Dewey's principles of "Experience and Nature" (1925) and "Experience and Education" (1938), advocating the transformation of schools into real-life environments and the ability of students to reach the targeted level of knowledge and skills in interactive environments (Duch et al., 2001; Savin-Baden & Howell-Major, 2004). Its theoretical foundations are based on Jean Piaget's "cognitive constructivism" due to questioning and reconstructing past experiences, Jerome Bruner's "discovery learning" due to directing students to discover information beyond memorization, and Albert Bandura's "social constructivism" principles due to collaborative endeavors (Duch et al., 2001; Savin-Baden & Howell-Major, 2004).

Gorghiu et al. (2015) identified 10 principles for PBL and emphasized that the desired learning objectives will be reached with the application of these principles: In the PBL process, while student-centered learning ensures active participation of students in the process, learning in stimulating environments enables their access to resources. Purposeful learning results in usable gains by working on real-life problems and active experiential learning directs students to research to improve their competencies. Rational learning focuses on developing higher-order thinking skills while learning based on previous experiences considers the prior knowledge and experiences of students. Collaborative learning supports peer instruction and social skill development. Effective learning encourages students to make voluntary efforts to achieve lasting gains. Authentic learning motivates students and facilitates the transfer of gains by working on real-life problems. Holistic (interdisciplinary) learning values the use of knowledge and skills from different areas in solving problems. Kim (2019) visualized the PBL process as a 9-step cyclical flowchart that begins with the presentation of the problem and extends to the presentation of the results, focusing on the improvement of the solution (Figure 1).

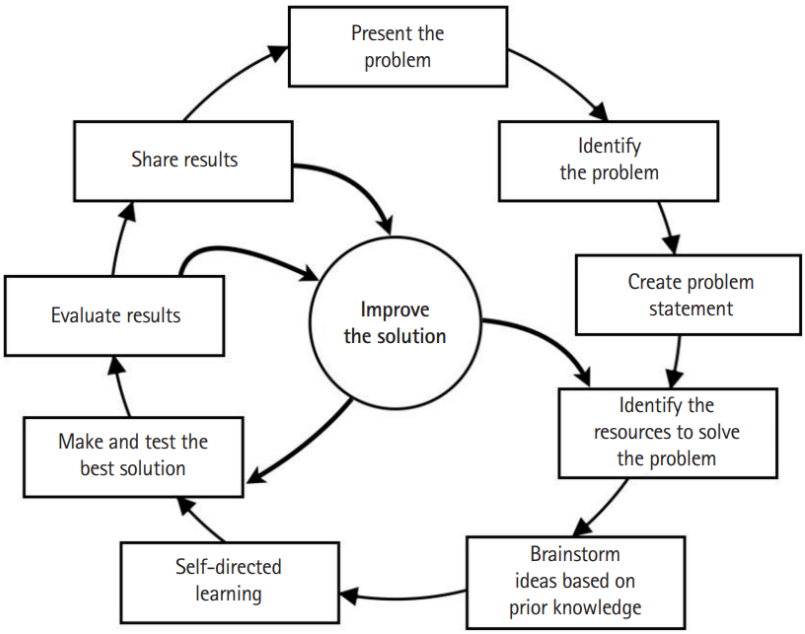

Figure 1. The PBL process (Kim, 2019)

According to the findings of meta-analysis research (Alacapınar & Ok, 2020; N. Ayaz, 2015; Batdı, 2014; Dağyar, 2014; Jensen, 2015; Leary, 2012; Özgül, 2021), the PBL method has a high level of overall effect size (OES) on knowledge and skill development and a moderate level of overall effect size on attitude development compared to the TI method. However, due to the PBL method requiring more resources, it is important to consider the cost-benefit situation. It is suggested that resource-intensive methods like PBL should be used in dealing with subjects that are difficult to learn or have an interdisciplinary character within the framework of teachers' professional experiences.

Since 2005, with the preparation of curricula in Türkiye according to the constructivist education understanding, scientific research and teaching activities for student-centered teaching methods have become increasingly widespread. For example, between 2005-2022, 128 graduate studies on the 5E learning cycle model, 158 on problem-based learning, 153 on project-based learning, and 237 on argumentation-based learning were conducted (YÖK UTM, 2022). This research aims to analyze the contents of graduate studies comparing the effects of the PBL method on various learning products with the TI method carried out in Türkiye between 2009-2021, and to integrate their findings. This study is expected to contribute to (1) prioritizing PBL activities in updating curricula, (2) planning, implementation, and evaluation of action research that teachers will carry out in their schools, and (3) research comparing the effects of different teaching methods.

In the research undertaken, comprehensive research questions were developed concerning both qualitative and quantitative aspects in accordance with the guidelines provided by Fraenkel et al. (2012, p. 563). The objective was to explore and answer the following:

Research Question 1. What are the descriptive characteristics of graduate studies comparing the effects of PBL and TI methods conducted in Türkiye between 2009-2021?

1.1. How are the graduate studies distributed according to years, types, and research methods?
1.2. How are experimental intervention processes distributed according to learning levels, courses processed, implementation duration, number of students, dependent variable clusters of knowledge, skills, and feelings, and dependent variables in the clusters of knowledge, skills, and feelings?

Research Question 2. According to the findings of graduate studies conducted in Türkiye between 2009-2021, what are the general effect size (GES) values of the PBL method on dependent variable clusters of knowledge, skills, and feelings, the most frequently questioned dependent variables under the clusters of knowledge, skills, and feelings, and dependent variable clusters consisting of skills in the 21st-century competence frameworks?

Research Question 3. What are the integrated effect size (IES) values of the PBL method on academic achievement and attitude towards the course within the framework of the findings of meta-analysis research conducted in Türkiye?

Method

Research Design

In the conducted research, an exploratory sequential mixed research method, which includes descriptive scanning in the qualitative dimension and meta-evaluation techniques in the quantitative dimension, was used to reach descriptive and explanatory results related to the problem situation. This method involves collecting and analyzing qualitative data in the first stage to access detailed information about events, phenomena, situations, and trends, and collecting and analyzing quantitative data in the second stage to explain the relationships between variables (Trochim et al., 2016). Using only qualitative or only quantitative research methods leads to approaching the problem situation only subjectively or only objectively, resulting in the loss of detailed or holistic perspectives, and weakening conformity with reality (Cohen et al., 2018). In this study, the research method was applied, with an emphasis on comparing PBL with TI on various learning outcomes. The initial phase involved qualitative analysis, drawing from 74 postgraduate dissertations conducted in Türkiye between 2009 and 2021. This approach allowed for an in-depth exploration of methodologies in question. Subsequently, the study proceeded to the quantitative phase, where the relationships between variables were systematically examined.

Data Set

The research focused on graduate studies related to PBL conducted in Türkiye between 2009 and 2021. From the pool of 147 studies identified (YÖK UTM, 2022), 74 were found to contain descriptive and explanatory data pertinent to the research's problem statement. The final sample comprised 24 Ph.D. and 50 master's studies (See Appendix A), selected based on specific inclusion and exclusion criteria.

Inclusion Criteria:
Timeframe and Location: Studies conducted in Türkiye between 2009-2021.
Methodology: Utilization of a control group pretest-posttest quasi-experimental research method was mandatory.
Teaching Methods in Study: Both the control and experimental groups had to organize activities based on either TI or PBL methods.
Detailed Reporting: Comprehensive reports on the experimental process and comparison findings were required.
Data Analysis: Use of parametric tests in data analysis was necessary to ensure statistical robustness.
Exclusion Criteria:
Non-Compliance with Methodology: Studies lacking a control group pretest-posttest quasi-experimental research method were excluded.
Inconsistent Control Group Methods: Studies where the control group used teaching methods other than TI were not considered.
Data Analysis Method: Studies employing non-parametric tests were excluded, as parametric tests offer more reliable statistical analysis.

The counting method was employed to create the sample set, deemed appropriate due to the limited number of relevant studies and the feasibility of accessing all of them (Gliner et al., 2017). This approach ensures a comprehensive and methodologically consistent sample, enhancing the research's reliability and validity.

Data Analysis

Qualitative data analysis

Descriptive scanning involves assessing the levels of certain characteristics within the elements of the research population through a selected sample set, without any intervention in their natural structures and functioning (Krippendorff, 2019; Mayring, 2022). In this study, the distribution of graduate studies included in the sample set was examined based on the following criteria: the years in which they were conducted, their types, and the research methods employed. Furthermore, the distribution of these studies was also analyzed in terms of the experimental intervention processes they utilized. These descriptive analyses provide a comprehensive overview of the characteristics and trends present within the selected graduate studies, offering valuable insights into the research.

Quantitative data analysis

Meta-analysis refers to the integration of different study findings that contain the same dependent and independent variable sets and determining the effect of the independent variable on the dependent variable independently of the sample size (Martin & Bridgmon, 2012). In meta-analysis research, firstly, Cohen's d effect size values are calculated for each comparison where the effects of different levels of the independent variable on the dependent

variable are questioned. Then, the weighted average of Cohen's d effect size values is taken over the sample size, and the GES value and level, which indicates the form of differentiation occurring in the dependent variable free from effects arising from chance, are found (Patten & Newhart, 2018).

$$sd_{spoiled} = \sqrt{\frac{(n_{experimental} - 1)sd^2_{experimental} + (n_{control} - 1)sd^2_{control}}{n_{experimental} + n_{control} - 2}}$$

$$cohen's\ d = \frac{m_{experimental} - m_{control}}{sd_{spoiled}}$$

$$GES = \frac{\sum_i n_i.d_i}{\sum_i n_i}$$

Here; the experiment and control indices represent the experiment and control groups; *n*, *m*, and *sd* symbols respectively represent the number of students/elements/studies, arithmetic mean, and standard deviation values.

In interpreting the GES value, the criteria indicated by Cooper et al. (2019); Gough et al. (2017), and Murphy et al. (2014) are commonly used; Cohen's d < - 0.200 is negative, - 0.200 ≤ Cohen's d < 0.200 is insignificant, 0.200 ≤ Cohen's d < 0.500 is weak, 0.500 ≤ Cohen's d < 0.800 is moderate, 0.800 ≤ Cohen's d < 1.200 is high, 1.200 ≤ Cohen's d < 2.000 is very high, and 2,000 ≤ Cohen's d is considered colossal.

Meta-integration refers to the blending of different meta-analysis study findings that contain the same dependent and independent variable sets and the highly comprehensive determination of the effect of the independent variable on the dependent variable (Martin & Bridgmon, 2012). The weighted average of the GES values calculated in meta-analysis studies participating in meta-integration research over the sample size gives the IES (integrated effect size) value (Patten & Newhart, 2018).

$$\text{IES} = \frac{\sum_i n_i.GES_i}{\sum_i n_i}$$

The following operations were performed in the process of analyzing the quantitative data collected in the study:

1. For each of the 176 comparisons questioning whether the PBL method creates a significant difference compared to the TI method in the studies selected for the research sample, Cohen's d effect size values have been calculated.
2. To facilitate the interpretation of the results, dependent variables in the studies selected for the sample, which examined the differentiation situations in the experimental intervention process, were collected under the clusters of knowledge, skills, emotions, and GES values regarding the PBL method compared to the TBL method for each dependent variable cluster have been calculated.
3. In the studies selected for the research sample, GES values of the PBL method compared to the TI method have been calculated for academic success, scientific process skills, and attitude towards the course, which are the dependent variables most questioned in the knowledge, skill, and emotion clusters.
4. A GES value has been calculated for the PBL method compared to the TI method on a dependent variable set consisting of skills found in the 21st-century proficiency frameworks.
5. The findings of the 5 meta-analysis studies on PBL in the literature and the findings of the conducted research have been blended, and integrated effect size (IES) values of the PBL method compared to the TBL method on the dependent variables of academic achievement and attitude towards the course have been calculated.

Results

Qualitative Research Findings

It was observed that 147 graduate studies on PBL conducted in Türkiye between 2009 and 2021 consisted of 49 (33.33%) doctoral theses and 98 (66.67%) master's theses; 24 (48.97%) and 50 (51.02%) of the doctoral and master's studies, respectively, met the conditions for selection into the sample of the conducted research; and the distribution of selected, eliminated, and the total number of graduate studies did not show regular distribution according to years and types (Table 1). Studies using only qualitative research methods and studies using single-group quantitative research methods were excluded from the sample because they did not provide the data needed to clarify the problem statement of the conducted research.

Table 1. Selection of Postgraduate PBL Studies in Türkiye (2009-2021): Yearly Distribution in the Research Sample

Year	PhD		MA		Total	% (100.n/147)
	Included	Excluded	Included	Excluded		
2009	1	1	3	5	10	6.80
2010	4	0	8	2	14	9.52
2011	4	0	6	2	12	8.16
2012	3	7	1	5	16	10.88
2013	1	3	4	1	9	6.12
2014	1	2	4	4	11	7.48
2015	0	2	4	5	11	7.48
2016	1	2	0	4	7	4.76
2017	4	2	0	1	7	4.76
2018	0	2	4	5	11	7.48
2019	1	1	9	4	15	10.20
2020	2	1	4	5	12	8.16
2021	2	2	3	5	12	8.16
Total	**24**	**25**	**50**	**48**	**147**	**100.00**

It was found that between 2009 and 2021 in Türkiye, the most graduate studies on PBL were conducted in 2012 (f=16/147, 10.88%) and 2019 (f=15/147, 10.20%), and the least in 2016 (f=7/147, 4.76%) and 2017 (f=7/147, 4.76%). The most selected studies for the research sample were conducted in 2010 (f=12/74, 16.22%), 2011 (f=10/74, 13.51%), and 2019 (f=10/74, 13.51%), representing 43.24% (32/74) of the sample. The studies most excluded from the sample were conducted in 2012 (f=12/73, 16.44%), and the least in 2010 and 2011 (f=2/72, 2.74%).

In the same period, the most doctoral studies on PBL were conducted in 2012 (f=10/49, 20.41%), and the least in 2009, 2015, 2018, and 2019 (f=2/49, 4.08%). The most selected doctoral studies for the research sample were conducted in 2010, 2011, and 2017 (f=4/24, 16.67%), representing 50.00% (12/24) of the sample. The doctoral studies most excluded from the sample were conducted in 2012 (f=7/25, 28.00%), and none were conducted in 2010 and 2011 (f=0/25, 0.00%).

Most master's studies on PBL were conducted in 2019 (f=13/98, 13.27%) and the least in 2017 (f=1/98, 1.02%). The most selected master's studies for the research sample were conducted in 2019 (f=9/50, 18.00%), 2010 (f=8/50, 16.00%), and 2011 (f=6/50, 12.00%), representing 46.00% (23/50) of the sample. The master's studies most excluded from the sample were conducted in 2012, 2015, 2018, 2019, and 2021 (f=5/48, 10.42%) and the least in 2013 and 2017 (f=1/48, 2.08%).

Between 2009 and 2021 in Türkiye, of the doctoral and master's studies on PBL selected for the research sample, 17 (70.83%) and 27 (54.00%) were designed according to the mixed research method and 7 (29.17%) and 23 (46.00%) were designed according to the quantitative research method. The research methods used in graduate studies did not show a regular distribution according to years and types. There was a tendency to use the mixed research method in both doctoral and master's studies. It was concluded that the mixed research method was used more in doctoral studies than in master's studies (Table 2).

Table 2. Overview of Postgraduate PBL Studies in Türkiye (2009-2021): Yearly Distribution, Types, and Research Methods

Year	PhD		MA		Mixed		Quantitative	
	Mixed	Quantitative	Mixed	Quantitative	Total	%	Total	%
2009	1	0	2	1	3	4.05	1	1.35
2010	2	2	4	4	6	8.11	6	8.11
2011	1	3	1	5	2	2.70	8	10.81
2012	3	0	1	0	4	5.41	0	0.00
2013	1	0	3	1	4	5.41	1	1.35
2014	0	1	2	2	2	2.70	3	4.05
2015	0	0	2	2	2	2.70	2	2.70
2016	1	0	0	0	1	1.35	0	0.00
2017	4	0	0	0	4	5.41	0	0.00
2018	0	0	2	2	2	2.70	2	2.70
2019	1	0	8	2	9	12.16	2	2.70
2020	1	1	1	3	2	2.70	4	5.40
2021	2	0	1	2	3	4.05	2	2.70
Total	**17**	**7**	**27**	**23**	**44**	**59.46**	**30**	**40.54**

It was observed that between 2009 and 2021 in Türkiye, the distribution of graduate studies on PBL selected for the research sample was as follows according to the research method: in doctoral theses, it was mixed (f=17/24, 70.83%) and quantitative (f=7/24, 29.17%), and in master's theses, it was mixed (f=27/50, 54.00%) and quantitative (f=23/50, 46.00%).

In graduate studies on PBL conducted between 2009 and 2021 in Türkiye and selected for the research sample, it was found that experimental interventions were carried out mostly at the middle school level (f=43/74, 58.11%) and least at the associate degree level (f=1/74, 1.35%). They were mostly implemented in science (f=21/74, 28.38%) and math classes (f=20/74, 27.03%), and these two subjects represented 55.41% (41/74) of the total. They were conducted for 5 weeks the most (f=16/74, 21.62%) and there was a concentration in the 3, 4, 5, and 6-week durations (f=46/74, 62.16%). They were carried out in classes composed of 21-30 students the most (f=40/74, 54.05%) and in classes composed of 1-10 students the least (f=1/74, 1.35%) (Table 3).

Table 3. Postgraduate Research on PBL in Türkiye (2009-2021): Distribution by Types of Experimental Interventions

Experimental Intervention Mode	(f)	(%)
Level		
Primary school	4	5.41
Middle school	43	58.11
High school	8	10.81
Associate's degree	1	1.35
Bachelor's degree	18	24.32
Subject		
Science	21	28.38
Mathematics	20	27.03
Other	15	44.59
Duration (Weeks)		
1-2	4	5.40
3-4	18	24.32
5	16	21.62
6-7	14	18.92
8 weeks and above	22	29.73
Class Size		
1-20	7	9.46
21-30	40	54.05
31-40 arası	18	24.32
41-50 arası	6	8.11
51 ve üzeri	3	4.05

In graduate studies on PBL conducted between 2009 and 2021 in Türkiye and selected for the research sample, it was found that the significant differences created by the PBL method compared to the TL method were mostly investigated in the knowledge dimension (f=83/176, 47.16%). In terms of independent variables, they were investigated the most in the academic achievement in the knowledge dimension (f=59/83, 71.08%), scientific process skills in the skills dimension (f=14/46, 30.43%), and attitudes toward the course in the affective dimension (f=30/47, 63.83%). Among the 21st-century competencies, problem-solving skills were the most investigated (f=9/46, 19.57%).

Table 4. Postgraduate Studies on PBL in Türkiye (2009-2021): Comparing PBL and TI Methods by Dependent Variables

Experimental Intervention Approach	(f)	(%)
Set of Dependent Variables		
knowledge	83	47.16
skills	46	26.14
emotions	47	26.70
total	176	100.00
Knowledge Dimension		
academic achievement	59	71.08
retention of knowledge	17	20.48
conceptual understanding	7	8.43
total	83	100.00
Skill Dimension		
scientific process skills	14	30.43
problem-solving skills	9	19.57
critical thinking skills	6	13.04
creative thinking skills	6	13.04
other types of skills	11	23.91
total	46	100.00
Emotion Dimension		
attitude towards the lesson	30	63.83
motivation toward the lesson	6	12.77
other affective characteristics	11	23.40
total	47	100.00

Quantitative Research Findings

In graduate studies on PBL conducted in Türkiye between 2009 and 2021 and selected for the sample of this research, it was found that among the comparisons of 7 groups investigating the significant differences created by the PBL method compared to the TI method, the effect size was mostly high (f=40/176, 22.73%) and least negatively (f=12, 6.82%) (Table 5). In the selected sample of graduate research on Problem-Based Learning (PBL) conducted in Türkiye from 2009 to 2021, comparisons across 7 groups investigating the significant differences yielded by the PBL method in contrast to the Traditional Instruction (TI) method revealed that the effect size was predominantly high (f=40/176, 22.73%) and least frequently negative (f=12, 6.82%), as detailed in Table 5.

Table 5. Comparison of 7 groups: Effect Levels in PBL vs. TI Methods

Effect Size (Cohen's d)	Effect Level	f	%
Cohen's d < - 0,200	In a negative direction	12	6.82
- 0,200 ≤ Cohen's d < 0,200	Insignificant	30	17.05
0,200 ≤ Cohen's d < 0,500	Weak	19	10.80
0,500 ≤ Cohen's d < 0,800	Moderate	34	19.32
0,800 ≤ Cohen's d < 1,200	High	40	22.73
1,200 ≤ Cohen's d < 2,000	Very high	23	13.07
2,000 ≤ Cohen's d	Huge	18	10.23

The integration of findings from graduate studies conducted in Türkiye between 2009 and 2021, selected for this research sample, reveals that the PBL method, compared to the TI method, demonstrates significant effects. The PBL method shows a high level of effect (0.992) in the knowledge dimension, a medium level of effect (0.696) in the skills dimension, a weak level of effect (0.406) in the emotional dimension, and a medium level of effect (0.734) in total.

Among the most studied dependent variables, the PBL method has a high level of effect on academic success (0.842), a weak level of effect on scientific process skills (0.351), and a weak level of effect on attitude towards the course in the emotional dimension (0.402). Additionally, the PBL method demonstrates a high level of effect size (0.799) on the set of skills aligned with the 21st-century competency frameworks. These findings indicate the effectiveness of the PBL method in enhancing knowledge, skills, and attitudes in educational settings. The meta-analysis studies on Problem-Based Learning (PBL) in literature, including works by Alacapınar and Ok (2020), Ayaz (2015), Dağyar (2014), Batdı (2014), and Özgül (2021), along with the meta-synthesis of these findings (Cooper et al., 2019; Gough et al., 2017; Murphy et al., 2014), indicate that the PBL method significantly impacts academic success with a high effect size of 0.857. Additionally, it shows a moderate effect size of 0.601 on attitudes towards courses when compared to the Traditional Instruction (TI) method, as detailed in Table 6.

Table 6. Meta-Analysis of PBL vs. TI Methods: Effect Size and Significance

	Effect size found in the research Overall effect size		The number of studies examined or sample size (SS)		Weighted effect size (WES) (WES = OES x SS)	
Research	Academic achievement	Attitude toward the lesson	Academic achievement	Attitude toward the lesson	Academic achievement	Attitude toward the lesson
Alacapınar & Ok (2020)	0.821	0.914	32	24	0.077	0.207
Ayaz (2015)	1.162	0.769	30	22	0.102	0.160
Batdı (2014)	1.302	-	26	-	0.099	-
Dağyar (2014)	0.620	-	118	-	0.214	-
Özgül (2021)	0.979	0.426	77	30	0.220	0.121
Studies Conducted(2023)	0.842	0.402	59	30	0.145	0.114
Total			342	106	**0.857**	**0.601**

Discussion

The research focused on synthesizing and examining the outcomes of postgraduate research that assessed the impact of PBL and TI methods on different learning outcomes, specifically emphasizing studies that utilized parametric statistical tests for data analysis. This analysis covered research conducted in Türkiye from 2009 to 2021. To streamline the interpretation of the experimental results, the dependent variables examined during the intervention phase of these studies were systematically categorized into specific groups. These groups included various aspects of learning, such as knowledge, skills, and emotional dimensions, thereby providing a structured framework for facilitating the interpretation of the results.

A total of 147 graduate studies on the PBL method conducted in Türkiye between 2009 and 2021 were reached, of which 74 (50.34%) were determined to contribute to the clarification of the problem sentence were selected, and the remaining 73 (49.66%) were eliminated from the sample. Due to the acceleration of developments in scientific research methods since the late 20th century, the patterns used in scientific research are diversifying as much as possible and the usage rate of the pretest-posttest experimental research method with a control group is gradually decreasing. Moreover, due to the diversification of the characteristics expected from individuals in the increasingly complex life conditions of the 21st century, the dependent variables questioned in education research are increasing and diversifying over time. The increase in methodological and purposeful diversity in scientific research reduces the rate of being selected into the sample in meta-analysis studies based on the quantitative research tradition and increases the elimination rate. Similar to the findings of the research conducted, in meta-analysis studies conducted by Alacapınar and Ok (2020), Batdı (2014), Dağyar (2014), and Özgül (2021) aimed at determining the ES value and level of the PBL method on academic achievement, it was stated that only 25/44 (56.82%), 118/180 (65.56%), 118/252 (46.83%), and 77/239 (32.22%) of the reached research were selected into the sample, respectively.

Between 2009 and 2021 in Türkiye, graduate studies on the PBL method included 49 doctoral dissertations (33.33%) and 98 master's theses (66.67%). Of these, 24 doctoral dissertations (48.97%) and 50 master's theses (51.02%) were chosen for a sample in a specific study. The fewer doctoral dissertations, compared to master's theses, can be attributed to the more extended, demanding nature of doctoral studies, which require more resources and have fewer enrolled students. In similar content analysis studies on PBL, the proportion of doctoral dissertations in the samples were as follows: Ayaz and Ayaz (2015) - 26.56%, Biber et al. (2014) - 29.69%, Erdoğan (2017) - 37.62%, Mutlu and Aydoğmuş (2019) - 32.50%, Temel et al. (2015) - 22.41%, Tosun and Yaşar (2015) - 30.00%, and Yıldırım and Say (2020) -

17.86%. These studies similarly reflect a trend of a lower number of doctoral dissertations compared to master's theses. This consistent pattern across various studies indicates a broader academic trend, suggesting that while PBL is a popular subject for graduate research, the complexities and demands of doctoral-level study result in a naturally lower output of dissertations in this area compared to master's theses.

In the doctoral dissertations on PBL conducted in Türkiye between 2009 and 2021, 17 out of 24 (70.83%) used mixed research methods, while 7 out of 24 (29.17%) used quantitative methods. In contrast, among the master's theses, 27 out of 50 (54.00%) employed mixed methods, and 23 out of 50 (46.00%) used quantitative methods. The mixed research approach is beneficial as it combines multiple evidence sources, integrates objective and subjective perspectives, and compensates for the main method's limitations (Christensen et al., 2015). However, due to its complexity, requiring expertise in both quantitative and qualitative methods, and the significant investment of time, effort, and resources, it is more commonly utilized in doctoral dissertations. It has been noted that postgraduate studies on the PBL method in Türkiye are unevenly distributed over the years in terms of types and research methods. This irregularity is partly due to the lack of a cohesive education research policy in Türkiye. This absence leads to fragmented scientific studies, making it challenging to draw comprehensive conclusions on the subjects researched. It also causes inconsistencies in sample sets for meta-analysis research and diminishes the relevance of longitudinal studies to real-world situations.

In Türkiye, from 2009 to 2021, it was observed that in selected postgraduate studies, experimental interventions were primarily focused on middle school students, with 43 out of 74 interventions (f=43/74, 58.11%) taking place at this level. These interventions were mainly in science (f=21/74, 28.38%) and math (f=20/74, 27.03%) classes, typically spanning a period of 5 weeks (f=16/74, 21.62%), and conducted in classes of 21-30 students (f=40/74, 54.05%). This pattern could be influenced by several factors: adherence to the Ministry of National Education's (MEB) guidelines in Türkiye, which stipulate non-disruption of educational processes, the low average academic performance in science and math in the High School Entrance Exam (LGS), the typical duration of middle school science and math units being 4-5 weeks, and the common class size range. In terms of the effectiveness of the PBL method compared to TI, the studies analyzed dependent variables in three clusters: knowledge, skill, and emotion. The PBL method was found to create a significant difference in 47.16% of cases in knowledge (f=83/176), 26.14% in skill (f=46/176), and 26.70% in emotion (f=47/176). The focus was mainly on academic achievement (f=59/176, 33.52%), scientific process skills (f=14/176, 7.95%), and attitude towards the course (f=30/176, 17.05%). The emphasis on knowledge-related variables is largely due to the assessment and evaluation methods used in Türkiye, which primarily assess cognitive aspects, thereby directing researchers to predominantly investigate variables in the knowledge cluster.

John Dewey, in 1938, highlighted the critical importance of both in-depth content mastery and skill development in educational settings, advocating for their integration in both research and practice. This approach emphasizes personal growth and self-realization. However, an analysis of postgraduate studies in this field reveals a skewed emphasis: a majority of these studies concentrated on the impact of the PBL method on content knowledge (47.16% of studies), while relatively fewer explored its influence on skill development (26.14%). Echoing Dewey's comprehensive approach, Slavin (2018) pointed out the crucial role of affective elements in the learning process, noting how students' perceptions of their learning environment can significantly affect educational outcomes. Similarly, Woolfolk (2016) argued for the necessity of a robust affective component in learning environments to facilitate cognitive development and ensure effective knowledge retention and application. Yet, the analyzed studies insufficiently addressed the impact of PBL on emotional development (26.70% of studies). The current research also reveals a gap in aligning with the 21st-century competencies, which emphasize skills vital for navigating complex life challenges and solving unpredictable problems. These competencies have become a focal point in global education systems and research. Nonetheless, the studies reviewed in this sample set show a lack of thorough exploration of the PBL method's effectiveness in developing skills outlined in these competency frameworks (15.34% of studies), particularly overlooking the areas of communication and collaboration skills entirely. This overview suggests a need for a more balanced research approach, one that equally values knowledge acquisition, skill development, and emotional growth in line with a holistic educational vision.

The comparative analysis of the PBL and TI methods reveals that PBL exhibits varying GES values across different educational dimensions. Specifically, the PBL method shows GES values of (a) 0.992, 0.696, 0.406, and 0.734 for knowledge, skills, emotions, and overall clusters respectively, (b) 0.842, 0.351, and 0.402 for the frequently researched variables of academic achievement, scientific process skills, and attitude towards the course in the knowledge, skill, and emotion dimensions respectively, and (c) 0.799 for the skill cluster included in the 21st-century competency frameworks. The learner-centric approach of the PBL method facilitates the achievement of high to medium effect sizes in the knowledge and skills dimensions within a relatively short period. However, the development of affective features, such as attitudes and emotions, appears to require longer educational interventions than those implemented in the selected studies, resulting in a weaker effect size in this area. Additionally, students' feedback on the experimental intervention processes in the studies predominantly praised the activities rather than the courses

themselves, indicating that while PBL can effectively engage students, more efforts are needed to create a positive attitude towards the courses themselves. This observation highlights the necessity for a more holistic approach in educational interventions, aiming not only for knowledge and skill acquisition but also for the cultivation of positive emotional and attitudinal responses toward learning.

Data from the Ministry of National Education (MEB, 2022) and the Measurement, Selection and Placement Center (ÖSYM, 2022) indicate underwhelming performance averages in the High School Entrance Exam (LGS) for Science and Math, as well as the Transition to Higher Education Exam (YGS) in Physics and Math. This trend suggests that middle and high school students in Türkiye may be struggling to develop a robust understanding and application skills in these subjects, pointing to a potential need for substantial reforms in the educational system. Despite efforts since 2005 to align curricula with constructivist learning principles, several challenges persist. These include a predominant focus on cognitive aspects in assessment and evaluation systems, a disconnect between curricula and real-life applications, inadequate school resources like labs and libraries, limited support from school administrations, insufficient parental involvement, gaps in pre-service and in-service teacher training, and a tendency among teachers to adhere to familiar teaching methods (as highlighted in studies by Akıncı et al., 2015; İpek et al., 2021; Saraç & Yıldırım, 2019). Consequently, TI based on behavioral learning principles continue to be widely employed. However, there is an opportunity for more effective teaching approaches. Teachers, drawing from their professional experience, might choose TI for topics where direct narration and a question-answer approach are deemed most effective. Conversely, they might opt for the PBL method for subjects where students face learning challenges and which require more resources. Such strategic use of teaching methodologies could potentially enhance educational outcomes.

Conclusion

The analysis of graduate studies in Türkiye from 2009 to 2021 offers significant insights into the effectiveness of PBL and TI methods in education. While PBL shows promise in enhancing academic achievement, critical thinking, problem-solving, and creative abilities, it is clear that the method's impact varies across different learning dimensions including knowledge, skills, and emotions. The studies indicate a stronger effect of PBL on knowledge and skills, yet its influence on emotional aspects requires more prolonged interventions for substantial impact. This disparity highlights the need for a more integrated approach in teaching methodologies, balancing cognitive, affective, and skill-based learning to align with the holistic vision of education. PBL activities establish a strong foundation for enhancing academic achievement by immersing students in real-world problems, encouraging responsibility and critical thinking, and making abstract concepts accessible and applicable across various contexts. PBL's active engagement in learning promotes motivation and self-regulation, helping students overcome fear of errors, share openly, and appreciate diverse perspectives. This approach effectively removes affective barriers to learning and contribute to the development of critical skills such as creative thinking within scientific limits, problem-solving through practical solutions, collaboration in teamwork, and communication through knowledge sharing. Importantly, PBL aligns with 21st-century competencies by supporting an integrated framework of knowledge, skills, and emotions. However, the implementation and effectiveness of PBL depend on the professional competencies of teachers and the resources available to them. High-quality pre-service and in-service training, sufficient resource allocation, and support from school administrations are pivotal for the widespread adoption of PBL and the realization of curriculum goals. The persistence of TI methods in Türkiye, despite a shift towards constructivist principles, reveals systemic challenges including resource constraints, limited teacher training, and an emphasis on cognitive assessments. Addressing these issues through strategic interventions such as comprehensive teacher development and curriculum reform is essential for a balanced and effective education system. To address the complex demands of today's rapidly changing world, it is essential to develop educational practices. A balanced approach that integrates PBL with TI can create a more dynamic and effective learning environment. This integrative approach ensures that students master content but also develop crucial skills for the 21st century, such as adaptability, collaboration, and innovation. Focusing on holistic student development, the education system can prepare learners more effectively for the diverse challenges and opportunities they will face in the future. As a result, this integrative and comprehensive educational approach is key to supporting individuals who are not only knowledgeable but also capable of thriving in a rapidly changing global environment.

Contributions of the Researchers

All authors contributed to the manuscript equally.

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Conflict of Interest

The authors have disclosed no conflict of interest.

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Appendix A. Graduate studies selected for the data set

Researcher	Year	University	Type	Design	Level	Lesson	Duration	Participant
Gökhan Serin	2009	ODTÜ	PhD	Mixed	Primary	science	5 weeks	34
Alper Altunçekiç	2010	Gazi	PhD	Quantitative	bachelor's degree	education	6 weeks	30
Cemal Tosun	2010	Atatürk	PhD	Mixed	bachelor's degree	chemistry	5 weeks	36
Gülden Akın	2010	Ankara	PhD	Mixed	bachelor's degree	English	9 weeks	22
Özlem Şahbaz	2010	D. Eylül	PhD	Quantitative	secondary	science	9 weeks	35
Beyza Bayrak	2011	Marmara	PhD	Quantitative	secondary	science	5 weeks	28
Canan Dilek Eren	2011	Marmara	PhD	Quantitative	bachelor's degree	physics	11 weeks	24
Kani Ülger	2011	Gazi	PhD	Quantitative	secondary	visual arts	9 weeks	36
Ömer Faruk Özkesen	2011	Atatürk	PhD	Mixed	bachelor's degree	chemistry	5 weeks	38
Elvan İnce Aka	2012	Gazi	PhD	Mixed	bachelor's degree	chemistry	9 weeks	41
Esen Ersoy	2012	D. Eylül	PhD	Mixed	bachelor's degree	statistics	6 weeks	30
Tolga Erdoğan	2012	Hacettepe	PhD	Mixed	bachelor's degree	education	15 weeks	36
Pınar Çelik	2013	D. Eylül	PhD	Mixed	bachelor's degree	physics	12 weeks	21
Aslıhan Kartal Taşoğlu	2014	D. Eylül	PhD	Quantitative	bachelor's degree	physics	7 weeks	24
Betül Özaydın Özkara	2016	Gazi	PhD	Mixed	associate degree	vocational	8 weeks	15
Elif Çelik	2017	Atatürk	PhD	Mixed	secondary	maths	6 weeks	27
Gülseda Eyceyurt Türk	2017	Gazi	PhD	Mixed	bachelor's degree	chemistry	8 weeks	44
Meryem Konu	2017	Atatürk	PhD	Mixed	high school	biology	7 weeks	59
Yücel Çetin	2017	Gazi	PhD	Mixed	high school	maths	4 weeks	24
Seda Aktı Aslan	2019	İnönü	PhD	Mixed	secondary	computer science	8 weeks	35
Nuray Topal Germi	2020	O. Mayıs	PhD	Mixed	secondary	science	5 weeks	25
Uluhan Kurt	2020	Atatürk	PhD	Quantitative	secondary	science	9 weeks	37
Faruk Arıcı	2021	Atatürk	PhD	Mixed	secondary	science	5 weeks	31
Hüseyin Bayram	2021	Anadolu	PhD	Mixed	secondary	social science	10 weeks	21
Aslıhan Kartal Taşoğlu	2009	D. Eylül	MA	Mixed	bachelor's degree	physics	3 weeks	23
Pınar Akın	2009	Ege	MA	Mixed	secondary	maths	6 weeks	24
Tülin Özsarı	2009	Ege	MA	Quantitative	primary	maths	10 weeks	24
Ayfer Karadaş	2010	D. Eylül	MA	Mixed	bachelor's degree	biochemistry	3 weeks	24
Ayşegül Bayram	2010	Selçuk	MA	Quantitative	secondary	science	3 weeks	27
Elif Çelik	2010	Gazi	MA	Quantitative	secondary	science	5 weeks	21
Esra Benli	2010	Gazi	MA	Mixed	bachelor's degree	education	8 weeks	35
Mesut Kuşdemir	2010	M. Kemal	MA	Mixed	high school	chemistry	9 weeks	26
Nazan Yıldız	2010	Marmara	MA	Quantitative	secondary	science	8 weeks	39
Neşe Uygun	2010	Gazi	MA	Quantitative	secondary	maths	6 weeks	30
Ümit Çimen	2010	Yıldız	MA	Mixed	secondary	computer sciences	3 weeks	29
Adem Ayvacı	2011	Kastamonu	MA	Quantitative	secondary	maths	3 weeks	42
Alime Şahin	2011	Atatürk	MA	Quantitative	bachelor's degree	physics	8 weeks	41
Ayşe Çağıl Kayıpmaz	2011	Kocatepe	MA	Quantitative	secondary	Turkish	4 weeks	32
Gülnur Özdil	2011	Kastamonu	MA	Quantitative	secondary	maths	4 weeks	24
Mehtap Eski	2011	Kastamonu	MA	Quantitative	secondary	maths	2 weeks	20
Pınar Çetin	2011	D. Eylül	MA	Mixed	primary	life sciences	6 weeks	33
Ahmet Elbistanlı	2012	M. Kemal	MA	Mixed	high school	chemistry	6 weeks	30
Ayşe Tuğba Tetik	2013	M. Akif	MA	Mixed	primary	social science	5 weeks	24
Derya Şencan	2013	Marmara	MA	Quantitative	secondary	science	6 weeks	33
Erkan Özcan	2013	D. Eylül	MA	Mixed	bachelor's degree	biology	4 weeks	47
Niyazi Sezer	2013	Uludağ	MA	Mixed	secondary	maths	2 weeks	20
Coşkun Karaca	2014	Atatürk	MA	Quantitative	secondary	social sciences	5 weeks	29

Gülcan Uyar	2014	Çukurova	MA	Mixed	secondary	maths	8 weeks	39
Meltem Kuvaç	2014	İstanbul	MA	Quantitative	bachelor's degree	environmental education	10 weeks	24
Ozan Emre Demirel	2014	M. Kemal	MA	Mixed	high school	chemistry	5 weeks	20
Caner Dursun	2015	Pamukkale	MA	Quantitative	secondary	science	6 weeks	22
Makbule Keleş	2015	N. Erbakan	MA	Quantitative	secondary	science	3 weeks	21
Salih Çakır	2015	Gazi	MA	Mixed	secondary	maths	5 weeks	26
Vildan Kurt	2015	Marmara	MA	Mixed	secondary	maths	4 weeks	32
Ahmet Bayır	2018	Atatürk	MA	Mixed	high school	vocational	5 weeks	8
Atakan Çoban	2018	D. Eylül	MA	Quantitative	bachelor's degree	physics	1 week	30
Rukiye Aras	2018	B. Yıldırım	MA	Mixed	secondary	social science	6 weeks	25
Zeynep Güzel	2018	N. Erbakan	MA	Quantitative	secondary	science	4 weeks	22
Aytül Damla Tekin	2019	Marmara	MA	Mixed	secondary	science	4 weeks	23
Büşra Tuğçe Karabaş	2019	S. Koçman	MA	Mixed	secondary	science	4 weeks	20
Gözde Menten	2019	Çukurova	MA	Mixed	high school	maths	9 weeks	31
Hatice Büşra Erim	2019	N. Erbakan	MA	Mixed	secondary	religion	6 weeks	24
Mehmet Emin Seyran	2019	S. Demirel	MA	Quantitative	secondary	science	4 weeks	24
Serdal Günay	2019	Uşak	MA	Mixed	secondary	social sciences	4 weeks	23
Şeyma Yıldız	2019	Sakarya	MA	Mixed	secondary	science	5 weeks	30
Yavuz Macun	2019	Erciyes	MA	Mixed	secondary	maths	5 weeks	47
Zeher Dilek Öztürk	2019	Pamukkale	MA	Mixed	secondary	science	9 weeks	30
Aybüke Kara	2020	Fırat	MA	Quantitative	secondary	maths	3 weeks	30
Gökçe Boncukçu	2020	Mersin	MA	Quantitative	secondary	science	3 weeks	61
Gülgün Bakırlı	2020	S. Koçman	MA	Mixed	secondary	science	5 weeks	22
Tuğba Saygılı Yıldırım	2020	O. Mart	MA	Quantitative	secondary	computer science	5 weeks	104
Burcu Çimen	2021	Ordu	MA	Mixed	secondary	science	2 weeks	15
Büşra Nur Nerse	2021	Kocaeli	MA	Quantitative	secondary	science	8 weeks	30
Ersin Özkan	2021	Atatürk	MA	Quantitative	high school	chemistry	6 weeks	33