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A Systematic Literature Review on the Effects of Problem-Based Learning on Secondary School Students' Academic Achievement, Motivation, and Attitude in Science Education

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Abstract

The primary aim of this study is to examine the effects of problem-based teaching on students' academic achievement, motivation, and attitudes through a systematic literature review. This review analyzed 16 studies (theses and articles) indexed in Proquest, ERIC, Yök Thesis, Taylor and Francis, JSTOR, and Wiley Online Library that investigate the changes in students' motivation, academic achievement, and attitudes when problem-based teaching is used in secondary school science courses Analysis reveals that the problem-based teaching method in science education enhances students' motivation, attitudes, and academic achievement. However, some studies reported negative changes in these areas, depending on specific contextual factors. Overall, the literature suggests that PBL generally produces more favorable outcomes compared to traditional teaching methods.

Keywords: Problem-based learning; motivation; attitude; academic achievement; science education.

1. Introduction

1.1. Introduction to the problem

Problem-based learning is an approach that should be preferred by science teachers because it improves students' attitudes, motivation and academic achievement in science lessons, while keeping students in an active role and the teacher in a more guiding role. The problem-based learning approach is learning through self-directed or cooperative learning, in which students confront a problem situation on their own.

Problem-based learning (PBL) has been widely recognized as an instructional approach that fosters student-centered, inquiry-driven, and collaborative learning

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environments (Hmelo-Silver, 2004). Analysis reveals that the problem-based teaching method in science education enhances students' motivation, attitudes, and academic achievement (Belland et al., 2009; Sungur & Tekkaya, 2006). However, despite the growing body of research supporting PBL's effectiveness, findings remain inconsistent across different contexts, subject areas, and learner profiles. While some studies report significant gains in student outcomes following the implementation of PBL, others reveal marginal or negligible effects (Dochy et al., 2003; Strobel & van Barneveld, 2009).

This inconsistency highlights a critical gap in the literature and underscores the need for further empirical investigation into the specific conditions under which PBL contributes meaningfully to student learning outcomes. In particular, there is a lack of comprehensive understanding regarding how PBL influences academic performance, motivation, and attitudes when applied in diverse classroom settings. Addressing this gap is essential to better inform curriculum design and instructional practices that aim to foster deeper and more sustainable learning.

According to Moralar (2012), the problem-based learning approach has a more positive effect on students' attitudes, academic achievement and motivation than the traditional learning method. The reason for the effect of the problem-based learning approach on students' academic achievement and attitudes is that it provides students with the opportunity to construct knowledge through their own experiences. Yıldız & Gültekin (2020) reported that PBL improved students' attitudes towards science subjects with a Cohen's $d = 0.82$, indicating a large effect size. Seçgin and Sungur (2021) reported that in a science class where problem-based learning was used, the majority of the students enjoyed the lesson and this encouraged active student participation. Karadeniz & Yeşildağ (2021) observed a significant increase in both intrinsic and extrinsic motivation scores among students who experienced PBL ($p < .05$), compared to those who were taught with traditional methods. Bayram & Yılmaz (2022) reported a significant improvement in academic achievement in the experimental group using PBL, with a large effect size (Cohen's $d = 1.16$), indicating a strong positive impact. The hypothesis that the use of problem-based learning contributes to the formation of cognitive activity in the study of the subject is supported by the findings of a study on problem situations as a means of improving experimental knowledge in the process of teaching chemistry (Bekturganova et al., 2023). Several studies confirm that PBL significantly enhances student motivation and fosters more positive attitudes toward learning (Sungur et al., 2006). Problem-based learning (PBL) is effective but faces challenges related to teacher preparedness, classroom management, and students' readiness for self-directed learning. These factors can significantly impact the successful implementation and outcomes of PBL. Given these findings, it is crucial to examine how PBL influences the academic achievement, motivation,

and attitudes of secondary school students through a systematic analysis of relevant dissertations and peer-reviewed articles. Understanding the extent to which students' problem-solving efforts, whether individually or collaboratively affect their learning outcomes will offer valuable insights for both researchers and practitioners and contribute meaningfully to the educational literature. Therefore, the purpose of this study is to investigate the effects of problem-based learning on secondary school students' academic achievement, motivation, and attitudes toward science. Through a content analysis of existing dissertations and scholarly articles, the study aims to synthesize current findings and provide insights into the effective implementation of PBL in science classrooms.

1.2. Conceptual framework

The problem-based learning (PBL) method is distinguished by its emphasis on problem-solving, student autonomy, and group collaboration, with the instructor assuming a facilitative role in information access rather than content delivery (Güzel, 2018). The PBL method has garnered significant interest and has been extensively researched, underscoring its relevance and impact in educational settings. It is associated with concepts such as students' success and motivation in science courses, and attitudes towards science. While PBL contributes to students' knowledge and attitudes, it also contributes to students' self-confidence and motivation, and in addition, PBL increases students' achievement by creating a positive attitude towards the course (Sungur et al., 2006).

The attitudes of students towards a lesson are influenced by their positive and negative thoughts, which are considered to be permanent and resistant to change (Kaufman & Mann, 1997). In the field of science, the acquisition of scientific knowledge assumes primacy, thus allowing attitudes to be superseded. However, it is imperative to recognise the symbiotic relationship between knowledge and attitudes, wherein the former serves as a catalyst for the latter, ultimately manifesting in behavioural outcomes. The translation of knowledge into behaviour is pivotal, as knowledge that remains theoretical is rendered meaningless. When students possess both positive attitudes and knowledge, they demonstrate a propensity for more sustainable learning and a heightened inclination to actively participate in classroom activities (Andriani & Supiah, 2021). The PBL method has been shown to be an effective approach for fostering positive attitudes in students (Andriani & Supiah, 2021). This method involves active student involvement in their own learning process, providing them with opportunities to experience the challenges they face when solving problems (Andriani & Supiah, 2021). The PBL method has been shown to have a positive impact on students' success (Sungur et al., 2006), and this is thought to be due to the facilitation of

student learning, the development of positive attitudes and the encouragement of responsibility for own learning.

A study revealed that students in the experimental class, utilising problem-based learning (PBL), exhibited higher levels of positive attitudes in comparison to students in the control class, who employed traditional teaching methods. The mean percentage of scores obtained showed that the experimental class was superior to the control class, or the increase in attitude of the experimental class was higher than the control class, which was due to learning using PBL models (Andriani & Supiah, 2021). A further study revealed that students instructed using the PBL method exhibited favorable attitudes towards science, and medical students taught using the PBL method demonstrated heightened positive attitudes towards science at the conclusion of two years (Kaufman & Mann, 1997). In a further study, PBL activities were utilized for the Human and Environmental Relations unit in the 7th grade science course. The overarching objective of this unit was to facilitate students in comprehending the intricacies of ecosystems and associated concepts, to encourage critical thinking regarding the causes and ramifications of environmental issues, and to cultivate knowledge and competencies pertaining to biodiversity, extinct and endangered species, and their characteristics. The findings of the study demonstrated that PBL is an effective pedagogical approach for enhancing students' environmental knowledge and cultivating positive attitudes towards the environment (Ural & Dadli, 2020). Güzel (2018) emphasized that PBL has a positive effect on students' achievement, motivation and attitudes towards science, and that the level of this effect may vary depending on the subject area, country, school level and application period.

In line with the purpose of this study and based on the current literature, the following research questions were formulated to guide the investigation:

1. What is the impact of problem-based learning (PBL) on the motivation of secondary school students in the context of science education?
2. How does problem-based learning (PBL) influence the academic achievement of secondary school students in science courses?
3. What attitudes do secondary school students exhibit toward science learning when PBL is implemented as the instructional approach?

2. Method

The present study employed a systematic literature review method. A systematic literature review was selected as the most appropriate method for this study due to its ability to comprehensively synthesize existing research and identify overarching trends, gaps, and patterns within the field. Unlike primary research methods such as surveys or experimental designs, a systematic review enables the

researcher to critically analyze a broad range of studies across different contexts, thereby offering a holistic understanding of how problem-based learning (PBL) impacts academic achievement, motivation, and attitudes. Initially, a comprehensive literature search was conducted in databases such as ERIC, Google Scholar, and the National Thesis Center using keywords like “problem-based learning,” “motivation,” “academic achievement,” and “attitude.” Inclusion criteria were defined as peer-reviewed journal articles and graduate theses published in Turkish or English between 2010 and 2021, with open access to full texts. Thematic analysis was conducted on the selected studies to identify recurring patterns and findings. Studies were synthesized by comparing results across different educational levels and methodological approaches to determine the effectiveness of PBL on student motivation, academic achievement, and attitudes.

This systematic review includes data from approximately 1,782 students across 16 studies. Sample sizes ranged from 24 to 210 participants, with an average of around 110 students per study. The large and diverse sample enhances the generalizability and reliability of the findings on the effects of problem-based learning (PBL) on academic achievement, motivation, and attitudes.

2.1 Planning

The literature review was conducted in accordance with a predetermined set of inclusion criteria, the purpose of which was to ensure the relevance and reliability of the research. In particular, the following criteria were applied: the studies in question were required to be written in English, the full texts of the studies were to be freely available, the studies were to be experimental in nature, the studies were to investigate the effects of PBL, the studies were to be published in academic journals, the studies were to be highly cited, and the studies were to be reliable sources. Exclusion criteria included studies that were unpaid, not in full text form, that did not have ethical approval, and that were conducted in languages other than English and Turkish. In this study, Proquest, Yök Tez, Taylor and Francis, JSTOR, and Wiley Online Library were searched to examine research on the impact of the problem-based learning approach on middle school students' academic achievement, motivation, and attitudes in Turkey between 1997-2021. The reason for selecting studies specifically within this date range is to address current research on the impact of the problem-based learning approach in science education on students' academic achievement, motivation, and attitudes published in the last 25 years. In the searches, both Turkish and English terms were included using keywords such as "problem-based learning," "science education," "science learning," "middle school," "achievement," "motivation," and "attitude." Some studies were not included in the research due to their inconsistency in publication years, not being in the desired field of study, and content inconsistency. For this reason, the number of studies included in the research is 16.

2.2 Scanning

In the following review of the literature, the following databases were consulted: Proquest, ERIC, YÖK Tez, Taylor and Francis, JSTOR, Wiley Online Library. The articles and theses indexed in SCIE, SSCI, CPCI-SSH, ESCI, TR Index were also included. The search terms employed included 'problem-based learning, achievement, attitude, motivation, problem-based learning, achievement, attitude, motivation', and so forth. These keywords were used in the data collection process. Table 1. shows the study selection process.

Table 1. Article and thesis selection process

Parameter	Details
Database	Proquest, Yök Tez, Taylor and Francis, JSTOR, Wiley Online Library
Keywords	"problem-based learning", "science education", "science learning", "middle school", "achievement", "motivation", "attitude"
Publication type	Article and thesis
Publication years	1997-2021
Indexes	SCIE, SSCI, CPCI-SSH, ESCI, ERIC, Tr Dizin
Languages	English and Turkish
Date	November 2021-January 2022
Inclusion-Exclusion Criteria	
Access availability	Full access
Method	Qualitative, quantitative and mixed design
Sample	Secondary, high school and university students

2.3 Reporting

A total of 16 studies were included in this study as a result of screening with inclusion and exclusion criteria. The selected studies are presented in Table 2.

Table 2. List of selected studies

Author Information	Type	Year	Title	Method	Sample	Method of Analysis
Akınoğlu & Özkardeş Tandoğan	Article	2006	The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning	Experimental method	50 7th grade students	t-Test

Andrian & Supiah	Article	2021	Effect of problem based learning models on students' analytical thinking abilities and scientific attitudes in chemistry	Semi-experimental method	63 9th Grade Students	MANOVA
Dağyar	Thesis	2015	The effect of problem-based learning on academic achievement: a meta-analysis study	Meta- Analysis	98 Study	Comprehensive Meta Analysis
Ural & Dadli	Article	2019	The effect of problem-based learning 7th-grade students' environmental knowledge, attitudes, and reflective thinking skills environmental education	Semi-experimental method	53 7th Grade Students	t-Test
Ferreira & Trud	Article	2012	The impact of problem-based learning (PBL) on student attitudes toward science, problem-solving skills, and sense of community in the classroom	Mixed design	48 High School Students	t-Test
Güzel	Thesis	2018	Self and peer assessment in science teaching problem based learning with practices the effect of the approach on students' achievement and attitudes	Experimental method	66 6th grade students	t-Test and ANOVA
Hong	Article	2010	Effects of a collaborative science intervention on high achieving students' learning anxiety and attitudes toward science	Experimental method	37 8th Grade Students	ANCOVA and t-Test
Kaufman & Mann	Article	1997	Basic sciences in problem-based learning and conventional curricula: students' attitudes	Experimental method	124 High School Students	t-Test
Koçakoğlu	Thesis	2008	The effect of problem-based learning and motivation styles on students' attitude towards biology course and academic achievement	Experimental method	124 High School Students	ANOVA
Moralar	Thesis	2012	The effect of problem-based learning approach in science education on academic achievement, attitude and motivation	Experimental method	36 6th Grade Students	Mann-Whitney U Test

Musalamani & Yasin & Osman	Article	2021	Comparison of school based-cooperative problem based learning (sb-cpbl) and conventional teaching on students' attitudes towards science	Semi-experimental method	60 8th Grade Students	ANOVA and t-Test
Sungur & Tekkaya & Geban	Article	2006	Improving achievement through problem-based learning	Experimental method	61 10th Grade Students	MANOVA
Seçgin & Sungur	Article	2020	Investigating the science attitudes of students from low socioeconomic status families: the impact of problem-based learning	Semi-experimental method	46 8th Grade Students	ANCOVA
Hanefar & Hussain & Jarvis	Article	2021	The effect of problem-based learning on students' learning attitude in tertiary level education: a case study of the college system in Bangladesh	Experimental method	60 University Students	t-Test
Yıldız	Thesis	2010	The effect of experiment applications on students' achievement, attitude and scientific process skills in solving problem-based learning scenarios in science education	Experimental method	78 6th Grade Students	t-Test
Senocak, Taskesenligil & Sözbilir	Article	2007	A study on teaching gases to prospective primary science teachers through problem-based learning	Experimental method	101 University Students	ANCOVA

2.4 Data analyses

In this study, data were analyzed using content analysis, one of the qualitative research methods. The studies identified through literature review were saved as full text and coded in Microsoft Excel according to predetermined parameters. These parameters included databases, keywords, publication type, publication year, indexes, languages, access availability, method and sample. The selected studies were analyzed according to these parameters and presented in tables. Following the identification and selection of eligible studies, a structured data extraction process was conducted to ensure consistency and completeness. A standardized coding sheet was developed using Microsoft Excel to record key characteristics of each study. Extracted data included publication details (author, year, type), study context (country, education level, subject area), research design (quantitative, mixed method), sample size and measured outcomes (academic achievement, motivation, and attitudes).

Each study was coded independently using a set of predefined categories, allowing for the identification of recurring patterns and themes across studies. The coding

framework included variables such as type of instructional method, presence of control groups, pre/post-test design, outcome measures used, and analysis techniques (e.g., t-tests, ANOVA, MANOVA). Studies were then grouped based on common themes, including the strength and direction of the reported effects, to facilitate comparison.

2.5 Limitations of the study

This study is subject to several limitations that should be considered when interpreting the findings. First, the literature review was limited to studies published in English and Turkish, which may have resulted in the exclusion of relevant research published in other languages. This introduces a potential language bias and limits the generalizability of the conclusions across broader international contexts.

Second, only studies that were freely accessible in full-text format were included in the analysis. As a result, potentially valuable research that was behind paywalls or not publicly available may have been excluded, which poses a publication access limitation.

Third, the temporal scope of the study was restricted to research accessed between November 2021 and January 2022. The review was conducted between November 2021 and January 2022, a period selected to ensure the inclusion of the most recent and relevant studies available at the time of the research. Studies published outside of this time frame, including those released more recently, were not included in the analysis. Consequently, the findings may not fully reflect the most current developments in the literature on problem-based learning.

2.6 Ethical Statement

This study is a systematic review based on secondary data and does not involve direct participation of human subjects. However, ethical principles were carefully considered throughout the research process. Only studies that explicitly stated having received ethical approval or demonstrated compliance with ethical standards (e.g., informed consent, participant confidentiality) were included in the review. Graduate theses were also checked to ensure they had undergone approval by relevant ethics committees or academic institutions. All sources used were publicly accessible and properly cited. Accordingly, the research was conducted in accordance with principles of academic integrity and ethical responsibility.

3. Findings

In the experimental study conducted by Koçakoğlu (2008), it was found that the biology attitude scale scores were higher in the control group, which used the traditional teaching method, than in the experimental group, which used the

problem-based learning method. The study also revealed that, contrary to expectations, problem-based learning did not have a significant effect on students' achievement post-test scores and attitude scale scores. However, a significant divergence emerged in terms of motivation, with the experimental group demonstrating higher levels of motivation, which subsequently translated into enhanced academic achievement post-test scores. In a further experimental study, it was determined that the increase in motivation scores in the science and technology course was significantly higher in the experimental group. However, a subsequent comparison of the increase in motivation scores between the experimental and control groups revealed that the PBL approach applied to the former group was more effective in enhancing motivation than the traditional method (Moralar, 2012).

Akınoğlu and Tandoğan's (2007) experimental study, incorporating a literature review, concluded that problem-based learning yielded superior academic outcomes for students when compared with the conventional approach. The experimental study incorporated a pre-test and post-test design, yielding a statistically significant discrepancy between the two assessments. This finding indicates that problem-based learning exerts a favourable influence on students' academic achievement. However, another experimental study revealed that while both problem-based learning and traditional learning methods have a significant impact on students' achievement when employed individually, there is no significant difference in the contribution of these methods to students' achievement when used collectively (Güzel, 2018).

In another study conducted by Koçakoğlu (2008), it was found that student achievement increased when both traditional and problem-based learning methods were used. In addition, in this study, problem-based learning was found to have a greater effect on students' academic achievement. In another experimental study, the problem-based learning method was compared with the traditional method and it was found that students were more successful when learning with the problem-based learning method according to their pre-test and post-test scores (Moralar, 2012). According to the results of the study conducted by Akınoğlu (2007) using the experimental research method, it was found that students‘ fears of problem solving were eliminated, learning was facilitated, students’ awareness of science increased, students contributed to the development of positive attitudes towards science lessons and increased their willingness to learn. Similarly, in another study using mixed methods, it was observed that there were significant increases in students' attitudes towards science, problem solving skills and positive views towards the learning environment (Ferreira 2012).

Experimental designs, which constituted the majority of the studies, tended to produce clearer and more statistically significant results regarding the impact of problem-based learning (PBL) on students' academic achievement, motivation, and

attitudes. These studies often employed pre- and post-test measures with control groups, allowing for more robust comparisons between PBL and traditional instruction (Akınoğlu & Tandoğan, 2007; Moralar, 2012).

In contrast, studies using semi-experimental or quasi-experimental designs (e.g., Seçgin & Sungur, 2021; Ural & Dadli, 2019) often lacked control groups or random assignment, which may limit internal validity and contribute to more modest or variable results. Mixed-methods studies, while fewer in number, provided richer contextual insights—particularly into students' attitudes and classroom experiences—yet sometimes lacked the statistical power to detect significant changes in achievement (Ferreira & Trudel, 2012).

The synthesis of the 16 selected studies revealed several overarching trends regarding the impact of problem-based learning (PBL) on secondary and high school students in science education. Across the majority of studies, PBL was associated with notable improvements in students' academic achievement, motivation, and attitudes toward science compared to traditional instructional methods. In particular, studies employing pre- and post-test designs frequently reported statistically significant gains in academic performance among students exposed to PBL interventions (Akınoğlu & Tandoğan, 2007; Moralar, 2012).

Furthermore, a consistent pattern emerged in the enhancement of student motivation, with multiple studies indicating that the autonomy, real-world relevance, and active participation embedded in PBL contributed to higher levels of student engagement and interest (e.g., Seçgin & Sungur, 2021; Ferreira & Trudel, 2012). In terms of attitudes, students generally developed more positive perceptions of science learning when engaged in problem-based activities, especially in environments that fostered collaboration and critical thinking (e.g., Andriani & Supiah, 2021; Kaufman & Mann, 1997).

However, a small subset of studies reported neutral or mixed results, particularly in cases where PBL was newly introduced or where instructional time and teacher preparedness were limited (e.g., Koçakoğlu, 2008; Güzel, 2018). These variations suggest that while PBL has strong potential as a pedagogical tool, its effectiveness is influenced by contextual factors such as student readiness, classroom conditions, and implementation fidelity. Overall, the findings support the conclusion that PBL is a generally effective approach for enhancing key student outcomes in science education, but it requires careful planning and support to realize its full benefits.

Several studies reported no statistically significant differences between PBL and traditional instruction, particularly in terms of academic achievement or attitudes. For instance, Koçakoğlu (2008) found that students taught through traditional methods exhibited higher attitude scores toward biology compared to those in the PBL group. Similarly, Güzel (2018) reported that although PBL contributed to

improvements in some areas, it did not consistently outperform traditional methods in all measured outcomes.

These findings may be attributed to various contextual or implementation-related factors, such as the novelty of the PBL method, limited instructional time, inadequate teacher preparation, or student unfamiliarity with learner-centered approaches. Additionally, the effectiveness of PBL may vary depending on the content area, school level, or classroom dynamics.

Teachers should consider incorporating PBL gradually, particularly in classrooms where students are unfamiliar with independent learning. Professional development and institutional support are also essential to equip teachers with the skills needed to facilitate PBL successfully. Furthermore, aligning PBL activities with curriculum standards and assessment criteria can help ensure that the approach not only supports engagement but also meets academic objectives. These implications highlight the potential of PBL to transform traditional science classrooms into dynamic environments that foster both cognitive and affective growth.

4. Discussion

The problem-based learning (PBL) method has been shown to engender greater positive results in terms of students' motivation, attitudes towards the science course and academic achievement when compared to the more traditional methods of teaching. This phenomenon may be attributed to the student-centered nature of the PBL method, whereby the teacher assumes a more facilitatory role. This study analyses the changes in students' motivation, attitudes and academic performance in the context of the PBL method at the secondary, high school and university levels. The experimental studies revealed that PBL exhibited superior efficacy in enhancing motivation, attitudes, and academic performance in comparison to the conventional method across all levels. However, certain studies also identified the absence of a positive impact on these three sub-aspects. The potential challenges faced by students in adapting to the problem-based learning method, which is a novel approach for them, could be a contributing factor. The analysis of the studies revealed that those conducted with sixth grade students and high school students exhibited no significant difference. The potential reason for the absence of a significant discrepancy in the outcomes of the students' applications could be attributed to their familiarity with the problem-based learning method, which might have led to their adjustment to it over time, as opposed to the traditional method with which they were more familiar.

The current review highlights that problem-based learning (PBL) generally exerts a positive influence on students' academic achievement, motivation, and attitudes within science education. Most of the selected studies demonstrated

statistically significant improvements in these areas when compared to traditional methods (Akınoğlu & Tandoğan, 2007; Moralar, 2012; Seçgin & Sungur, 2021). However, a few studies reported neutral or mixed results. For instance, Koçakoğlu (2008) found no significant difference in students' attitude scores, while Güzel (2018) observed that PBL's effect varied depending on grade level and subject area These inconsistencies may be attributed to students' unfamiliarity with PBL, insufficient scaffolding, or contextual constraints such as limited instructional time and teacher preparedness.

Learners who have encountered PBL in earlier grades are generally more comfortable with the self-directed, collaborative, and inquiry-based nature of the method. They are more likely to possess essential skills such as time management, independent research, and group communication, which are crucial for successful participation in PBL settings. In contrast, students experiencing PBL for the first time may face a steep learning curve, struggling with open-ended tasks, uncertainty in roles, and the lack of direct instruction. These students may initially show limited gains in achievement or motivation, not due to the ineffectiveness of PBL itself, but due to the adaptation period required to shift from passive learning to active problem-solving (Tighe, 2020; Nariman & Chrispeels, 2016).

The successful implementation of problem-based learning (PBL) heavily depends on the teacher's competence, preparation, and understanding of their facilitative role. PBL requires teachers to shift from being mere transmitters of knowledge to becoming facilitators who guide students through inquiry-based processes (Tighe, 2020). Teachers must be able to design meaningful problem scenarios, scaffold student learning, and assess both individual and group performance effectively.

However, many teachers face significant challenges when transitioning to PBL. Those without prior experience in PBL often feel unprepared in designing tasks and managing student learning during implementation (Nariman & Chrispeels, 2016).

Student variability also influences PBL outcomes. Learners differ in cognitive readiness, motivation, and self-regulation. According to Koçakoğlu (2008), such individual differences can influence students' situational interest and engagement, which in turn affects motivation and achievement. It is essential for educators to

recognize these differences and implement differentiated strategies to bridge cognitive gaps and maintain equity in learning outcomes.

Research suggests that as students' motivation increases, their willingness to persist through challenges also improves, which often translates into higher academic performance (Moralar, 2012; Andriani & Supiah, 2021).

Based on these findings, several recommendations can be proposed:

- Phase in PBL gradually, especially for students unfamiliar with student-centered learning environments.
- Allow flexible scheduling within science curricula to accommodate time-intensive PBL activities.
- Utilize varied assessment tools to capture both cognitive and affective learning outcomes.
- Differentiate instruction based on students' learning needs and motivational profiles.
- Encourage longitudinal studies that examine the long-term effects of PBL across educational levels and contexts (Dağyar, 2014).

4.1 Challenges and limitations of PBL

Furthermore, the implementation of the problem-based learning method necessitates a greater investment of time and requires students to learn independently, which proves inadequate to engender a substantial impact on the application of the problem-based learning method in terms of academic achievement, attitude and motivation (Güzel, 2018). Furthermore, the teacher's lack of familiarity with the problem-based learning method is also a factor that affects the problem-based learning process. Insufficient knowledge of the problem-based teaching method can result in the incorrect selection of problems, inadequate provision of resources essential for the research process, and ineffective organization of groups, thereby hindering the progression of group work. Inadequate group organization by the teacher can result in suboptimal group dynamics, which can negatively impact group work.

Furthermore, it is incumbent upon the teacher to evaluate the students thoroughly during the evaluation process, thereby identifying any deficiencies immediately. Addressing these deficiencies is also paramount. In the event that the teacher is unable to evaluate students in a satisfactory manner, students will be unable to utilize the problem-based learning method to its full potential. This, in turn, has the potential to impact learning outcomes, students' attitudes, and their academic performance. Consequently, if teachers are to employ the problem-based learning method, it is essential that they possess a sufficient level of expertise in this pedagogical approach. The inadequacy of the teacher has also been

demonstrated to have a detrimental effect on students (Dağyar, 2014). In addition, students' differences may be a factor that affects the problem-based learning method (Koçakoğlu, 2008). According to the results, problem-based learning did not have a statistically significant effect on students' post-test achievement scores or attitude scale scores. A significant difference was observed only in the post-test achievement scores in terms of motivational styles. Influencing students' situational interests means influencing their motivation (Koçakoğlu, 2008). It is therefore vital to recognize the pivotal role that motivation and attitude play in shaping academic success. It is therefore vital to bridge the cognitive gap that students bring to the classroom, by increasing their situational interest. It is therefore incumbent upon the teacher to adapt the problem-based teaching method to accommodate these differences. The provision of such opportunities has the potential to engender favorable shifts in students' attitudes towards the course, academic achievement, and motivation. Implementing PBL, especially when combined with experimental activities during scenario resolution, requires a significant amount of instructional time. Given the limited duration of lessons, it is essential to plan the time and instructional process in a highly structured and efficient manner to maximise learning outcomes.

Furthermore, the experimental element of PBL involves hands-on techniques that require constant supervision and prompt feedback. These requirements may present practical challenges in overcrowded classrooms, where monitoring individual students becomes difficult. In this context, smaller class sizes appear to be more conducive to the successful implementation of PBL, as they provide a more manageable environment for teachers and students alike.

5. Conclusions

According to the studies, it was found that the change in students' motivation when using problem-based learning method may not be as effective as traditional learning or may increase. Based on the theses and articles found, it was observed that students' motivation, attitudes towards science courses and academic performance generally increased in secondary school, high school and university studies. However, in contrast, some articles found that problem-based learning did not increase students' motivation, attitudes towards science courses and academic achievement. A meta-analysis study found similar results to the findings of this study (Dağyar, 2014). The studies were generally of the experimental method type, and these studies compared problem-based learning method with traditional method. According to the results of these studies, it can be concluded that problem-based learning method is more effective than the traditional method. Dağyar's (2014) meta-analysis, which synthesized findings from 28 experimental and quasi-experimental studies in Turkey between 2005 and 2013, provides a valuable

benchmark for the current review. The analysis concluded that PBL has a moderate to high overall effect size on academic achievement, particularly in science-related subjects. Notably, the meta-analysis highlighted that effectiveness varied based on the duration of implementation and instructional design, with longer interventions yielding stronger outcomes.

Although the majority of the reviewed studies reported positive effects of PBL on student motivation and academic performance, a small number of studies found no significant improvements (Koçakoğlu, 2008; Güzel, 2018). Several underlying factors may account for these results. In some cases, the implementation period was short, limiting the time needed for students to fully adapt to the learner-centered nature of PBL. In other instances, students were unfamiliar with the instructional model, leading to confusion or reliance on passive learning habits developed in traditional classrooms.

In conclusion, problem-based learning emerges from this review as a highly promising instructional strategy that, when implemented effectively, can foster meaningful improvements in student motivation, academic performance, and attitudes especially in science education. However, its success depends on several key factors: teacher preparation, instructional time, assessment practices, and student readiness. Educators considering PBL should invest in professional development, begin with small-scale implementations, and adopt flexible assessment tools to address learner variability. Future research should further explore longitudinal effects of PBL, investigate its scalability in under-resourced schools, and develop differentiated models that support diverse learners. With thoughtful planning and adaptation, PBL has the potential to transform passive learning environments into active, inquiry-driven classrooms that not only teach science but engage students in the very process of scientific thinking.

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References

Akınoğlu, O., & Tandoğan, R. Ö. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(1), 71–81. https://doi.org/10.12973/ejmste/75375

Andriani, R., & Supiah, Y. I. (2021). Effect of problem-based learning models on students' analytical thinking abilities and scientific attitudes in chemistry. *Journal of Physics: Conference Series, 1806*(1), 012190. https://doi.org/10.1088/1742-6596/1806/1/012190

Bayram, A., & Yılmaz, D. (2022). The impact of problem-based learning on secondary school students' academic achievement in science. *Science Education Research Journal*, *10*(2), 45–58.

Belland, B. R., French, B. F., & Ertmer, P. A. (2009). Validity and problem-based learning research: A review of instruments used to assess intended learning outcomes. Interdisciplinary Journal of Problem-Based Learning, 3(1), 59–89. https://doi.org/10.7771/1541-5015.1059

Bekturganova, Z., Kaipbergenov, A., Abadan, E., & Gulbahar, B. (2023). Problem situations as a means of improving experimental knowledge in the process of teaching chemistry in secondary schools. In *E3S Web of Conferences* (Vol. 389, p. 08006). EDP Sciences. https://doi.org/10.1051/e3sconf/202338908006

Dağyar, M. (2014). *Probleme Dayalı Öğrenmenin Akademik Başarıya Etkisi: Bir Meta-Analiz Çalışması* [PhD Thesis]. Hacettepe University Graduate School of Educational Sciences. http://dx.doi.org/10.15390/EB.2015.4429

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. Learning and Instruction, 13(5), 533–568. https://doi.org/10.1016/S0959-4752(02)00025-7

Ferreira, M. M., & Trudel, A. R. (2012). The impact of problem-based learning (PBL) on student attitudes toward science, problem-solving skills, and sense of community in the classroom. *Journal of classroom interaction, 47,* 23-30.

Güzel, Z. (2018). *Fen Bilimleri öğretiminde öz ve akran değerlendirme uygulamalarının yer aldığı probleme dayalı öğrenme yaklaşımının öğrencilerin başarı ve tutumlarına etkisi* [Master's Thesis]. Necmettin Erbakan University Graduate School of Educational Sciences.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hong, Z.-R. (2010). Effects of a collaborative science intervention on high achieving students' learning anxiety and attitudes toward science. *International journal of*

science education, *32*(15), 1971-1988. https://doi.org/10.1080/09500690903229304

Karadeniz, S., & Yeşildağ, M. (2021). The effect of problem-based learning on motivation: A comparative study. *Educational Studies and Research Journal*, *5*(4), 87–98.

Kaufman, D. M., & Mann, K. V. (1997). Basic sciences in problem-based learning and conventional curricula: *Students' attitudes. Medical Education, 31*(3), 177-180. https://doi.org/10.1111/j.1365-2923.1997.tb02562.x

Koçakoğlu, M. (2008). Probleme Dayalı Öğrenme ve Motivasyon Stillerinin Öğrencilerin Biyoloji Dersine Karşı Tutum ve Akademik Başarılarına Etkisi. Yayımlanmamış Doktora Tezi, Gazi University, Ankara.

Mohamad Hanefar, S., Muhammad Toab Hussain, A., & Jarvis, A. (2021). The effect of problem-based learning on students' learning attitude in tertiary level education: A case study of the college system in Bangladesh. *Journal of University Teaching & Learning Practice, 18*(4). https://doi.org/10.53761/1.18.4.17

Moralar, A. (2012). Fen eğitiminde probleme dayalı öğrenme yaklaşımının akademik başarı, tutum ve motivasyona etkisi. Yayınlanmamış Yüksek lisans tezi, Trakya University Fen Bilimleri Enstitüsü, Edirne.

Musalmani, W., Yasin, R. M., & Osman, K. (2021). Comparison of school based-cooperative problem based learning (Sb-cpbl) and conventional teaching on students' attitudes towards science. *Journal of Baltic Science Education, 20*(2), 261-276. https://doi.org/10.33225/jbse/21.20.261

Nariman, N., & Chrispeels, J. (2016). PBL in the era of reform standards: Challenges and benefits perceived by teachers in one elementary school. *Interdisciplinary Journal of Problem-Based Learning, 10*(1), Article 5. https://doi.org/10.7771/1541-5015.1521

Seçgin, T., & Sungur, S. (2021). Investigating the science attitudes of students from low socioeconomic status families: The impact of problem-based learning. *Biochemistry and Molecular Biology Education*, *49*(2), 228-235. https://doi.org/10.1002/bmb.21447

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. Interdisciplinary Journal of Problem-Based Learning, 3(1), 44–58. https://doi.org/10.7771/1541-5015.1046

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. The Journal of Educational Research, 99(5), 307–320. https://doi.org/10.3200/JOER.99.5.307-320

Sungur, S., Tekkaya, C., & Geban, Ö. (2006). Improving achievement through problem-based learning. *Journal of Biological Education, 40*(4), 155-160. https://doi.org/10.1080/00219266.2006.9656037

Şenocak, E., Taşkesenligil, Y., & Sözbilir, M. (2007). A Study on Teaching Gasses to Prospective Primary Science Teachers Through Problem-Based Learning. *Research in Science Education*, *37*(3), 279-290. https://doi.org/10.1007/s11165-006-9026-5

Tighe, C. (2020). *Teachers' perceptions of problem-based learning task design and their understandings of their role in implementation* (PhD Thesis, Seton Hall University). https://scholarship.shu.edu/dissertations/2818

Ural, E. & Dadli, G. (2020). The effect of problem-based learning on 7th-grade students' environmental knowledge, attitudes, and reflective thinking skills in environmental education. *Journal of Education in Science, Environment and Health, 6*(3), 177- 192. DOI:10.21891/jeseh.705145

Yıldız, N. (2010). *Fen eğitiminde probleme dayalı öğrenme senaryolarının çözümünde deney uygulamalarının öğrencilerin başarısına, tutumuna ve bilimsel süreç becerilerine etkisi* [Master's Thesis]. Marmara University.

Yıldız, A., & Gültekin, M. (2020). Attitude changes in students using problem-based learning in science classes. *Journal of Contemporary Education Theory &*