REVIEW

Problem-Based Learning in Science Education: A Mixed Meta Method Study

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Abstract*: A mixed-meta analysis of research on problem-based learning in science education was the goal of this study. In this instance, document analysis utilizing the mixed-meta method—which combines meta-analysis and meta-thematic analysis procedures—was used to investigate both quantitative and qualitative data. Using CMA and MetaWin programs, studies from certain databases that fit predetermined criteria were analyzed for a meta-analysis. Of the 78 studies that were included in the study, the effect size was found to be large, with g = 0.909. It has been suggested that science education benefits from the problem-based learning approach. Within the framework of the established criteria, 15 researches based on document analysis were subjected to a meta-thematic analysis using the Maxqda program in accordance with content analysis. Codes were acquired based on specific topics. By calculating the compliance values of the relevant codes under the relevant themes, a good degree of agreement was found regarding the effects of problem-based learning in science education on academic achievement, the affective-social dimension, 21st century skills, and the negative aspects of problem-based learning in science education. The research results indicate that there is a consensus among the researchers regarding the benefits of using problem-based learning techniques in science education.*

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Introduction

TRADITIONAL educational approaches are increasingly insufficient in today's quickly changing environment. There is a growing need for teaching strategies that not only engage students actively but also incorporate modern approaches (Yurd & Olgun, 2008). The complexity of our current era, along with the overwhelming amount of information available, necessitates that individuals be equipped not just with rote knowledge but also with essential life skills. These skills are crucial for tackling real-world challenges (Çınar & İlik, 2013). Contrary to this, an outdated focus on the teaching abilities of educators, rather than on the learning capabilities of students' results in a passive educational experience that fails to prepare students for the complexities of daily life (Yaman & Yalçın, 2005).

It might be argued that the major purpose of science education is not only to teach students the essential principles of the topic but also to develop in them a curiosity and interest in science, as well as good attitudes, teamwork, and cooperation. These are critical for developing higher-level thinking skills and actively involving students in the learning process. Utilizing student-centered approaches and methods to keep the student actively involved in the process is more effective for achieving meaningful learning outcomes (Çınar & İlik, 2013). Furthermore, it is clear that our pupils require certain talents in order to succeed (Shamir, Zion, & Spector-Levi, 2008). Problem-based learning (PBL) is more effective than traditional teaching methods in achieving these goals (Çınar & İlik, 2013). It is known as the American educational theorist John Dewey, who systematized the concept of problem solving for the first time (Yıldırım & Yalçın, 2008). PBL has been systematized based on the view of learning by doing put forward by the American educator John Dewey (Koray & Araz, 2008). The PBL approach was initially developed at the university level in the field of medicine (Barrows & Tamblyn, 1980, cited by Chin & Chia, 2004), and then it started to be applied at all levels of education, from primary school to high school (Delisle, 1997, as cited in Chin & Chia, 2004; Şenocak, 2009). Student-centered and small group teaching for medical students PBL, which was designed, took its place in education and training programs ten years later (Kumar, 2010). Problem-based learning, which has been successfully implemented in many vocational education fields, was introduced at the primary and secondary education levels in 1990. In Turkey, it has been in use since 2000. According to Kılınç (2007), there have been numerous published research studies, articles, and theses on this approach. Research indicates that education based on the PBL approach outperforms traditional methods in several key areas. Specifically, it enhances student achievement and boosts their motivation towards coursework. Given these advantages, PBL has established itself as a student-centered approach that is increasingly considered essential in today's science education (Kaptan & Korkmaz, 2001).

It is seen that it is possible to instill the skills necessary in the 21st century in education in general and in science education in particular (Shamir, Zion, & Spector-Levi, 2008). In this respect, certain stages should be followed while applying the PBL approach. The first stage of PBL is the discovery and definition of the problem, which is a creative process (Chin & Chia, 2004). Then, it consists of stages such as determining the necessary information for the defined problem, determining the sources to reach the information, determining solution methods, evaluating the solutions, and reporting and presenting the solution (Shamir et al., 2008; Kaptan & Korkmaz, 2001). The most crucial of these stages is the identification of the problem situation. It is very important to organize this problem situation according to the student group and level. For example, while it is appropriate to give unstructured problems to gifted children, it is more appropriate to give less structured problems to students at the normal level (Boran & Aslaner, 2008). In addition to these, a good problem situation should not contain unrealistic information, should contain realistic clues that will lead to a solution, and should also arouse the student's curiosity with understandable language. The problem situation should also allow the student to use higher-order thinking skills (Sezen-Vekli, 2012).

In the PBL environment, the role of the teacher is just as critical as the problem scenario itself. Unlike traditional teaching methods, where the teacher acts as an authority figure, here the teacher serves more as a guide or facilitator (Kılınç, 2007). Among the roles of teachers in PBL, there are many such as being a guide, learning together with the student, ensuring the participation of the students, managing and directing the process, and revealing the thoughts of the students (Kaptan & Korkmaz, 2001). The fact that the teacher has these roles in PBL ensures that the student is central and active in learning, unlike traditional methods. Thus, the student becomes active in the learning process, fulfills the responsibilities brought by the problem, shares the information he has obtained with the class, and makes an effort to take on the necessary responsibilities in the groups.

One of the numerous benefits of problem-based learning is that it fosters student involvement and active participation. Thus, the student develops his/her own self-control skills and high-level thinking skills, develops a sense of responsibility and problem-solving skills in group work, and increases the motivation of the student (Kaptan & Korkmaz, 2001). Individuals gain problem-solving abilities as a result of PBL, and they use various and inventive techniques to solve the difficulties they face in their daily lives. At the same time, students have the opportunity to express their ideas freely and to communicate better with other people (Aygün, Atalay-Kılıç, & Yaşar, 2016). The importance of problem-based learning has increased day by day due to its many advantages for students. The importance of this approach in the literature has been stated in different studies, and many studies have been conducted on PBL in Turkey (Karadeniz-Bayrak and Bayram, 2012; Tatar and Oktay, 2009; Tosun and Taşkesenliğil, 2012; Şahbaz and Hamurcu, 2012; Kılıç and Moralar, 2015). In addition, it is seen that various studies have been conducted to determine the general trends in the use of problem-based learning in science education in Turkey (Tosun & Yaşar, 2015) and to compare these studies with the usage areas and trends in science education around the world (Tosun & Yaşar, 2013). In these studies, it was observed that the focus on the effect of PBL on learning. In addition, both meta-analysis and meta-thematic analysis methods were used together in studies to examine the effect of the flipped classroom method (Doğan, Batdı, & Yaşar, 2023) and project-based learning approaches in science education (Kılınç, Yaşar & Batdı, 2022). It was seen that the mixed-meta method was used. However, when the relevant literature is examined, it is seen that there are no detailed studies based on the mixed meta method for PBL in science education. This study also focused on the meta-analysis and meta-thematic analysis of studies on PBL in science education. Thus, a detailed examination of the applications of PBL in science education was made, and its presentation was made from a wider perspective.

Purpose of the Study

In this study, it was aimed to make a mixed-meta method in which meta-analysis and meta-thematic analysis of studies conducted in Turkey on PBL in science education are used together. The following research questions are posed in relation to the aims of this study:

1. In meta-analytic studies, what is the magnitude of the impact of Problem-Based Learning (PBL) on students' academic achievement in science education?
2. According to participant opinions, what are the effects of PBL applications in science education on: a). Academic performance; b). Affective-social dimensions; c). 21st-century skill development; d). potential drawbacks?"

Method

This research was carried out with the mixed-meta method, in which meta-analysis and meta-thematic analysis processes were used together. In order to determine the effectiveness of the problem-based learning method in science education, this research was conducted within the framework of the mixed-meta method, using the meta-analysis process in the quantitative dimension and meta-thematic analysis in the qualitative dimension. This method is aimed at dealing with both quantitative and qualitative data regarding document analysis in terms of integrity. In the mixed-meta method, while analyzing quantitative data with computer programs such as CMA and MetaWin; qualitative data is also analyzed with programs such as Nvivo and Maxqda. After the analysis, it provides the opportunity to combine and examine the products from these programs in a research. Therefore, it can be said that the mixed-meta method is a rich method (Batdı, 2020). The studies that we will include in the current mixed-meta research should be scientific as well as those that contain published and accepted quantitative or qualitative data (Batdı, 2021, p. 1218). In this study, meta-analysis and meta-thematic analysis of studies based on PBL in science education were made, and the related process was presented within the framework of two headings: meta-analysis process and meta-thematic analysis process.

Meta-Analysis Process

Meta-analysis studies can be expressed as the synthesis of studies that have been more generalized based on the principle of combining the results of studies that serve the same or related purpose and which have been confirmed by many studies (Büyüköztürk et al., 2018, p. 239). In these studies, conclusions are drawn by combining and interpreting the statistical findings from different studies with similar objectives using specialized methods. Therefore, studies to be included in meta-analysis studies should include statistical findings (Büyüköztürk et al. 2018, p. 239). In the quantitative phase of this research, a meta-analysis process was applied to determine the effectiveness of PBL in Science Education.

Data Collection

In this context, "problem-based learning/teaching methods in science education/teaching," etc., to reach the studies carried out in the literature on problem-based learning in science education. The databases of the National Thesis Center and Google Academy were searched by using keywords. Certain criteria were taken into account in the screening process. These criteria were included in the research, such as national or international publications, applications related to problem-based learning from science education, and examining the effects on students' academic achievement. In addition to these, values such as the arithmetic mean, number of samples, and standard deviation (x, n, ss) that contain data suitable for meta-analysis were also taken into account. The studies that included the determined criteria were added to the scope of this research, and the unsuitable ones were not included. As a result, a total of 130 studies, including 80 theses and

50 articles, were reached by considering certain criteria, and 51 of the 80 theses and 27 of the 50 articles were included in the meta-analysis.

Analysis of Data

Effect size is important in meta-analysis studies. The effect size is used to determine the effect value of the independent variable (causing) on the dependent variable (resulting). This value is determined according to the fixed effects model (SEM) and random effects model (Schmidt, Oh, & Hayes, 2009). The use of REM was preferred in the relevant research due to the limited availability of suitable conditions, according to SEM. While calculating this value, the "Cohen's d" and "Hedge's d" coefficients were used. In this study, the data in the meta-analysis study were conducted with the MetaWin and CMA 2.0 programs, and the level classification of Thalheimer and Cook (2002, p. 4-9) was taken into account in the interpretation of the Hedge's g value obtained. Accordingly, if the effect size is between 0.15 and 0.15, it is insignificant; between 0.15 and 0.40, it is small; between 0.40 and 0.75, it is moderate; between 0.75 and 1.10, it is large; between 1.10 and 1.45, it is very large; and 1.45 and above, it is excellent (Thalheimer and Cook, 2002, p. 3-9).

Meta-Thematic Analysis Process

In the study, it was aimed at obtaining wide and rich data by integrating the findings of qualitative studies by making meta-thematic analysis within the scope of the second dimension. Meta-thematic analysis, based on document analysis, is often used in the social sciences. Meta-thematic analysis can be expressed as a process that involves obtaining qualitative studies on a specific subject related to document analysis, re-analyzing the raw data in these studies, and re-creating themes and codes (Batdı, 2019; 2020). In this context, the statement of Büyüköztürk et al. (2018) that a holistic perspective is obtained by organizing descriptive information and revealing themes in a comprehensible way in terms of thematic analysis supports the meta-thematic analysis process. In this study, it is aimed at creating a more comprehensive perspective on the research subject by making a meta-thematic analysis in addition to the meta-analysis in terms of a holistic understanding. Thus, in the research conducted, 15 studies that met certain qualitative criteria were added to the meta-thematic analysis process.

Data Collection and Analysis

In this research, data on the effectiveness of problem-based learning in science education were obtained with the document analysis technique.

Document review requires the analysis of all written materials that provide information about the case(s) that are planned to be investigated. It allows obtaining a holistic picture of the researched subject by associating the obtained information with each other within a certain framework (Yıldırım & Şimşek, 2018, p. 188).

In this research, the contents of the studies that meet the appropriate conditions according to the criteria determined in the qualitative sense were examined in detail, and similar and common aspects were created. Thus, the analyzed data were classified by considering their structural and semantic common aspects and were interpreted and re-interpreted. As a result, studies containing raw data based on qualitative document analysis were reconsidered, interpreted, and presented with content analysis. In this process, qualitative data were obtained by analyzing the Mawqda-11 program.

Coding

Coding is an important process in meta-thematic studies. It can be defined as the process of coding and deciding on categories. The categories should be clear so that other researchers can come to the same conclusions when examining the same study. In published articles and theses, the researcher focuses on his particular research topic and establishes categories. Identifying categories is a very difficult process. Coding can be done by hand on paper as well as by using computer software. In computer coding, basic office software can be used in addition to word processors. These programs are like Caqdas, Maxqda, or NVivo. These are software programs specially developed for qualitative data analysis (Büyüköztürk et al. 2018, pp. 261-262). In this study, the meta-thematic analysis process was carried out with the Maxqda-11 program. The analysis identified five themes: the impact of PBL on "academic achievement," "affective dimension," "social dimension," "twenty-first century skills," and "negative aspects." These themes were grouped, affective and social dimensions were handled under a group and given under the same model, and qualitative data were presented by creating a total of 4 models.

Reliability in the Meta-Thematic Analysis Process

It is a known fact that qualitative researchers will never be able to capture "truth or reality," that is, objectively. Therefore, qualitative researchers use a number of strategies to increase the "credibility" of their findings (Merriam, 2015, p. 205). At this point, in order to ensure and increase credibility, triangulation using multiple data sources, that is, comparing and crossing the obtained data with people with different perspectives, is required. The involvement of more than one researcher in the processes of collecting and analyzing data in the same study is defined as researcher triangulation (Merriam, 2015, p. 206). In this research, from the beginning to the end, the two researchers acted together and exchanged ideas in the data collection, analysis, interpretation, and reporting processes. Another approach is expert review or expert review. Examining the article and giving recommendations by an expert who is knowledgeable about the subject and methodology of the research also contributes to its credibility (Merriam, 2015, p. 210). In this study, opinions were received from a second expert researcher during the analysis, coding, and interpretation of the study, and necessary arrangements were made within these opinions. In addition to these, direct quotations from the analyzed sources and data for the themes and codes created were included in the meta-thematic analysis. While interpreting the findings, these direct quotations were included. The sources from which the codes and themes are taken are represented by "M" articles, while Council of Higher Education [CHE] national theses are coded with their own numbers. For example, '187146 p.71' refers to the direct quote on page 71 of the thesis numbered 187146 in CHE.

Results

In this section, the findings obtained by the mixed-meta method for problem-based learning in science education are included and interpreted. Meta-analyses of quantitative data and meta-thematic analyses of qualitative data were made and presented.

Findings Related to the Meta-Analysis Process

Table 1 contains the findings regarding the meta-analysis process. According to the findings, the effect level in the calculations done using REM within the scope of the influence of PBL on the academic achievement of students in science education is 0.909 [0.737; 1.081]. This level of influence was determined at a large level in terms of the classification made by Thalheimer and Cook (2002, p. 3-9), and this revealed the conclusion that PBL has a positive effect on the academic success of students in science education. In addition, when **Table 1** is examined, it is seen that the effect size for academic achievement (Q = 701.158; p.05) shows a heterogeneous distribution according to the heterogeneity test value.

Figure 1 reflects the Funnel Plot data. This graph was obtained with the MetaWin and CMA data analysis programs, and there is the possibility of publication bias in the visual dimension of the results of the meta-analysis data set in the graph (Cooper et al. 2009, p. 428). In the analyses made with CMA or MetaWin programs, sometimes there may be deviations or

Table 1. Meta-Analysis Table.

			95% Confidence Interval		Heterogeneity		
Models	**n**	**G**	**Lower**	**Upper**	**Q**	**P**	**I²**
SEM	78	0,669	0,613	0,725	701,158	0	89,018
REM	78	0,909	0,737	1,081			

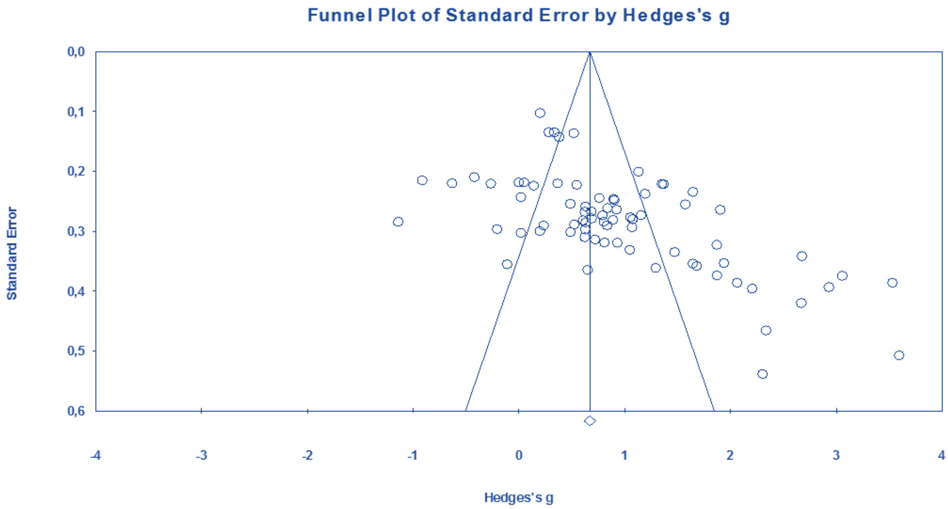

Figure 1. Funnel Plot plot (Funnel Scatterplot).

scattering in the effect size (Borenstein et al. 2009, p. 278). In this study, Funnet Plot results were examined to detect publication bias. According to the results, a value of 4561 was found, and this calculated value is the number of error protections used to minimize or eliminate publication bias in the meta-analysis process [Fail-safe (FSN)] (Rosenthal, 1979, p. 638). The value of 4561 obtained as a result of the calculations indicates that the bias can be reduced to zero by including 4561 studies in the current study. However, since this value is too high, it is not possible to reach this value. Therefore, it has been concluded that the relevant value does not contain publication bias since it requires a number of studies that are unlikely to be achieved (Cheung & Slavin, 2011, p. 288) and the data obtained by meta-analysis is quite reliable.

Findings Related to the Meta-Thematic Process

In the meta-thematic analysis phase of the research, models created for the themes and codes of the data obtained from the qualitative studies carried out

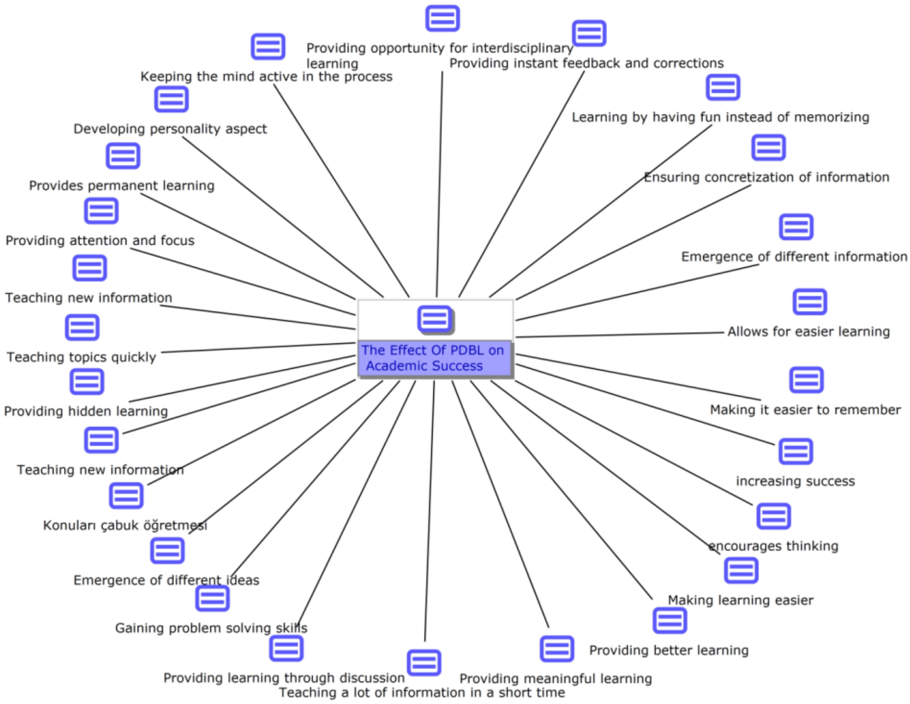

Figure 2. The Effect of Problem-Based Learning (PBL) on Academic Achievement.

to support problem-based learning in science education were included. As a result of the analysis, it has been determined that it consists of themes such as the effect of the PBL on "academic success," "the affective-social dimension," "21.yy skills," and "negative aspects" of the PBL, and the codes of these themes.

Figure 2 shows the codes for the effect of PBL on academic achievement. When the effect of PBL on academic success was examined, it was seen that expressions and codes such as "*Providing permanent learning, providing meaningful learning, increasing success, and learning with fun instead of memorization*" came to the fore. The expressions and codes of scientific studies that constitute a source in the creation of the codes of the effect of PBL on academic success "*…1. It was very good that I got an exam 59 and a second exam 90. My teacher is density, broken heart, d = m/v. Now, when I say broken heart, this is the first thing that comes to my mind. I don't forget anymore. (451230, p. 135) "; "I was interested in problem-based learning. Nice method. We learn in an entertaining way. We started to love problem solving. We learn the definitions according to the cartoon characters. I'm in favor of continuing education like this. (191667, p. 121)*". In addition, other codes are detailed in **Figure 2**.

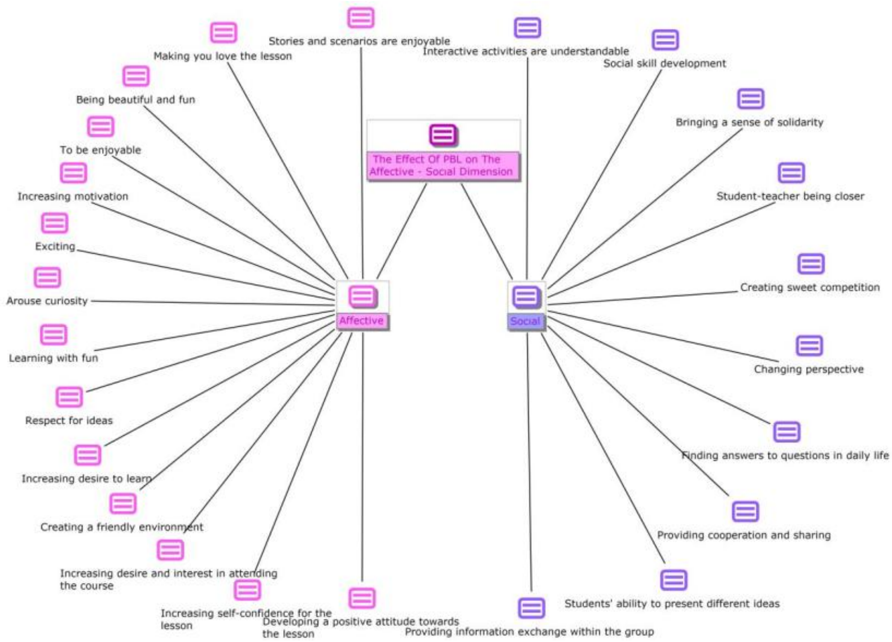

Figure 3. The Effect of Problem-Based Learning (PBL) on Affective-Social Dimension.

In **Figure 3**, the effect of PBL on the affective-social dimension is given as two themes. As can be seen in **Figure 3**, some of the codes related to the effect of PBL on the affective dimension are "*Increasing motivation, arousing curiosity, developing a positive attitude towards the course,*" etc., codes can be given as examples. Examples of direct quotes from these codes are "*I felt good; sometimes I got excited because I was curious. Trying to solve the question is instructive… It wasn't boring, it was enjoyable… (504726, p. 246)*"; "*…It has changed; it has become more fun; my love has increased. The previous method was tedious (506216, p. 97)*".

As can be seen in the second part of **Figure 3**, some codes related to the effect of PBL on the social dimension were determined as "*student-teacher being closer, helping, sharing, and gaining a sense of solidarity*". Direct quotations for these codes are "*We were spending more time with our teacher and we were doing research on different things (487946, p. 83)*"; "*…Yes. Because it is very important to get the ideas of our friends and share them with them (313398, p. 151)* "; "*Working in the group is good. It provides solidarity. It enables working together. Intimacy grows. I enjoyed being in a group (562135 p. 101).*" Other codes for the effect of PBL on affective-social dimensions are given in **Figure 3** in detail.

In **Figure 4**, the codes obtained regarding the effect of PBL on the 21st century are shown. Some of the codes related to the effect on their skills

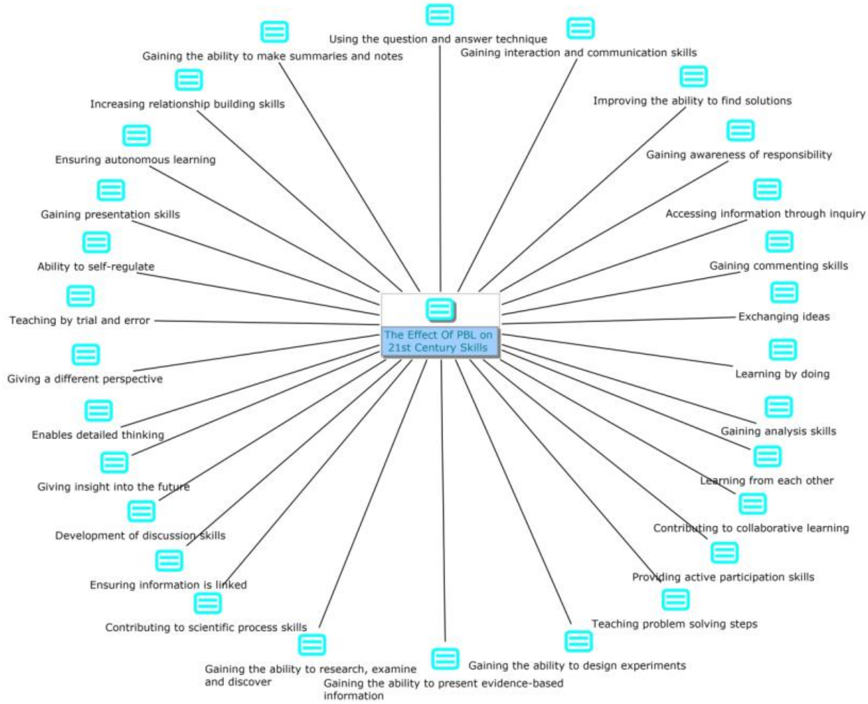

Figure 4. The Effect of Problem-based Learning (PBL) in the 21st century skills.

were determined as "*growing awareness of responsibility, contributing to collaborative learning and contributing to scientific process skills.*". Some of the expressions and direct quotations that can be references to these codes are "*positive aspects: everyone knew and fulfilled their own responsibilities. More importantly, he sought help from his friends and tried to understand the subjects he did not understand. Negative aspects: When I assigned them as the group leader, they did not care about me and did not fulfill their duties…*" (487946 p. 83) (T23); "*Teacher, we are processing this ourselves, I did not understand the cell part very well, I did not understand it much because you explained it. I understood this unit better because we worked with the group here (451230 p. 135)* "; "*… In today's world, where science and technology are developing at an incredible rate, giving such applications in lessons contributed to the development of our scientific process skills, which are an important component of science and technology literacy. Especially such applications made it easier for me to experiment, so my interest in the laboratory increased (343967 p.153)*". Other codes for the effect of PBL on 21st-century skills are given in **Figure 4**.

Apart from the advantages of the problem-based teaching method in different aspects, it has been determined by analyzing the data that there are

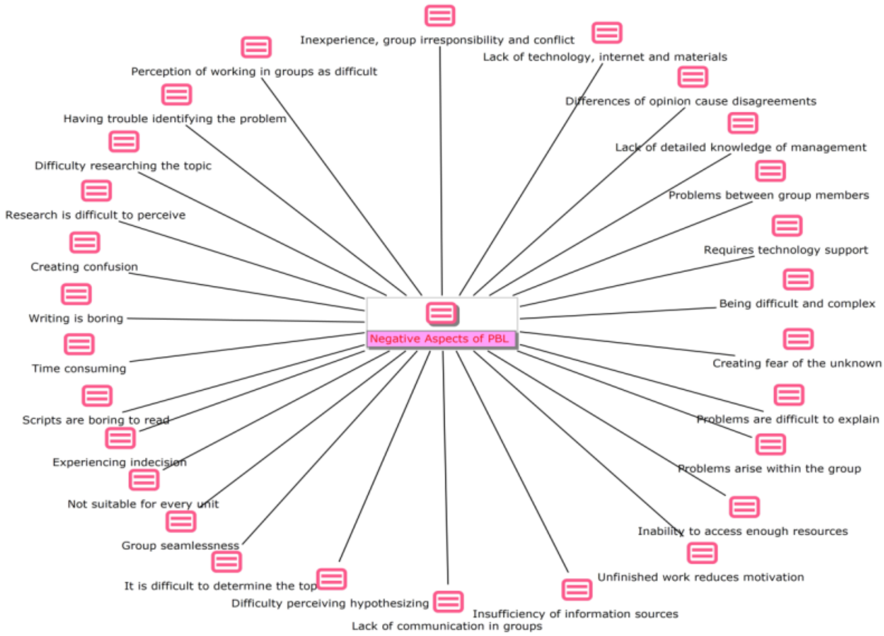

Figure 5. Negative Aspects of the Problem-Based Learning (PBL).

some negative aspects to this subject. In **Figure 5**, the codes related to the negative aspects of PBL are seen. Some of these codes were determined to be "*time consuming, group irresponsibility, insufficient information resources and lack of communication in groups.*" Some of the expressions and direct quotes that can refer to these codes are "*Actually, it is productive. But it's time-consuming. How many hours did I spend trying to solve the problem? There are additional questions, and I'm dealing with them. Time passed quickly before I could finish the topic (504726 p. 272)*"; "*Sir, we are working well with the group, but now M is doing something; M does not agree much; he makes fun of him; he acts according to his head; and because of him, we are discredited. (451230 p.132)* "*Positive: do not work as a group. Negative: lack of information resources (487946 p. 83)*"; "*The possible lack of communication between the members of the groups formed (200888 p. 70)*". Other codes related to the negative aspects of PBL are given in **Figure 5**.

Conclusion and Discussion

In this study, the effect of PBL in science education was determined by the mixed-meta method. This method is based on document analysis. Thus, the meta-analysis of the quantitative studies on PBL in science education and the meta-thematic analysis of the qualitative studies were carried out together. In this context, it is aimed at evaluating the studies made with the PBL in science education with mixed-meta method. In this section, the data obtained as a result of the analyses are discussed by comparing them with the results of other studies in the literature. In the first stage of the research, which was based on document analysis, quantitative data were determined by meta-analysis, and qualitative data were identified and presented in the second stage using meta-thematic analysis. The study, which was conducted concurrently with the research method, took a complementary and comprehensive approach. When the meta-analysis data were examined, it was concluded that PBL in science education had a positive and significant effect (g = 0.909) on the academic achievement of students. This suggests that the experimental group's PBL activities are more effective at improving academic achievement than the control group's traditional practices. In addition, when the obtained value (g = 0.909) was compared with the level classification values determined by Thalheimer and Cook (2002, p. 4-9), it was concluded that this effect value was positive, large, and significant. When the results obtained in this study are compared with the study of Çınar and İlik (2013) in the literature, similar results were obtained, and it was concluded that PBL increased the success of the students in the 6th grade "Electricity Directing Our Lives" unit in a positive and meaningful way.

In order to support and complement the results obtained from the meta-analysis, according to the results of the meta-thematic analysis of the data obtained from the qualitative studies, themes and codes related to the effectiveness of PBL in science education were obtained. Models were created for the themes and codes created. One of these themes is to determine the effect of PBL on academic achievement in science education. When the effect of PBL on academic achievement in science education is examined, it is concluded that codes are formed such as providing permanent learning, latent learning, that is, learners have knowledge involuntarily, and providing meaningful learning by discussing. As a result, when the findings obtained from this research were evaluated, it was understood that the problem-based teaching method increased the success of the learners, provided learning with fun instead of memorizing, and provided opportunities for easier learning. When the relevant literature is examined, it is seen that there are various studies that have a positive effect on the academic achievement of PBL in science education (Çayan & Karslı, 2014; Çelik, Eroğlu & Selvi, 2012; Demirel & Arslan-Turan, 2010; İnel & Balım, 2010; Peterson & Treagust. 1998; Tatar and Oktay, 2011; Uluçınar-Sagir, Yalçın-Çelik and Öner-Armağan, 2009; Yurd and Olğun, 2008) and it was concluded that these studies are in parallel with the current research findings. Thus, according to the results of this research, which is also supported by the literature, it can be concluded that PBL increases the academic success of students in science education. The second theme derived from the thematic analysis findings is to determine the impact of PBL on the affective-social dimension of science education. In this context, it is understood from the interpretation of the codes obtained that PBL in science education increases the willingness and interest of learners to participate in the lesson, shows a positive attitude towards the lesson, gives a sense of solidarity among students, and makes the lesson fun with a sweet competition. When the relevant literature was reviewed, similar and parallel results were achieved with the current research. As a matter of fact, Çelik, Eroğlu, and Selvi (2012) concluded in their study that PBL practices in science education develop a positive attitude towards science education in students. In addition, in the study conducted by Tosun and Taşkesenliğil (2012) and Aydoğdu (2012) with science teaching students, it was concluded that PBL increased students' motivation and attitudes towards the lesson and made a positive contribution.

The data collected through meta-thematic analysis sheds light on another topic: the impact of problem-based learning in science education on 21st-century skills. The research results indicate that this approach contributes to learners' scientific process skills, enhances their communication abilities, fosters collaborative learning, and facilitates experiential learning. In other words, it equips learners with the skill of active participation. The literature contains a variety of studies that support the current research findings. As a matter of fact, in their study, Yaman and Yalçın (2005) examined the effect of PBL on the creative thinking levels of teacher candidates, one of the 21st century skills. At the end of the application, it was discovered that the pre-service teachers in the experimental group improved their creative thinking skills more than the students in the control group. Based on these findings, it can be inferred that the Problem-Based Learning (PBL) approach is more effective in enhancing creative thinking compared to traditional teaching methods. The last theme is the negative aspects of the problem-based teaching method in science education, one of the themes obtained in the mixed-meta study in line with the meta-thematic analysis, in addition to its positive aspects and contributions to learning. In this context, it has been determined that the challenges are difficult and complex, that there are conflicts among group members, and that there are negative features such as inexperience, arguments, group irresponsibility, time- consumption, and a shortage of materials. For this reason, in order to create healthier educational environments, it is important and recommended to eliminate the problems encountered in the problem-based teaching method in science education and to remove the obstacles.

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