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Effects of Problem-Based Learning on Attitude: A Meta-analysis Study

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To date, researchers have frequently investigated students' attitudes toward courses supported by problem-based learning. There are several studies with different results in the literature. It is necessary to combine and interpret the findings of these studies through a meta-analysis method. This method aims to combine different results of similar and independent studies through statistical techniques. Research findings of 47 studies that meet the criteria for meta-analysis are included in the meta-analysis of the study to determine the effects of problem-based learning on students' attitudes as compared to traditional teaching. Also, some mediator variables are as follows: the status of a study, application time, education levels, scientific field of application, and sample size. As a result of the analysis, it has been found that problem-based learning has a low positive effect on students' attitudes. It means that problem-based learning is effective in helping students gain a positive attitude toward courses.

Keywords: attitude, effect size, meta-analysis method, problem-based learning

INTRODUCTION

In education systems, it has long been considered that students have different learning capacities and skills. Students who learn easily were regarded as having the skills to learn, and those who have difficulties with learning were believed to have no such learning skills or be unintelligent. This situation has begun to change in the late 20th century, and theories have been proposed claiming that all students without learning difficulties or mental health problems have the capacity to learn all new behaviors taught in schools (Fidan, 1996). In these theories or models, it has been emphasized that teaching–learning processes should be regulated in such a manner to cover cognitive, affective, and psychomotor properties of students as a whole (Bloom, 1956). The cognitive domain (where mental skills of students are developed), the affective domain (where dimensions such as interests, attitudes, motivations,

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concerns, consciousness, personality, and standard of judgments of students are developed), and the psychomotor domain (where all psychomotor skills are developed) are complementary parts. In this regard, all these teaching–learning activities should be planned and applied in accordance with the development of such domains (Demirel, 1999; Gömleksiz, 2003). In this context, when a convenient environment is created for teaching–learning, everyone can participate in the learning process according to his or her individual speed of learning. Every person can learn everything taught in school, at home, etc.; there is no individual, even a child, without learning skills (Bloom, 1956). However, it appears that applications used in the education system neglect affective dimensions in comparison to cognitive and psychomotor dimensions (Gömleksiz, 2003; Özmen, 1999). Yet, an individual does not learn only at the moment of study. Permanent attitudes, admirations, and discontents are caused by additional learning, and this is as important as learning in school, perhaps even more important because these attitudes affect an individual's life in the long term.

State of the literature

- In the literature, researchers have frequently investigated the effect of problem-based learning on students' attitudes toward courses as compared to traditional teaching in individual studies.
- However, there are few studies that have combined the findings of individual studies to determine the effects of problem-based learning on students' attitudes when compared to traditional teaching in studies through meta-analysis in the current literature.
- Meta-analysis can combine the statistical analysis of the quantitative findings of independent and similar studies to determine the results clearly.

Contribution of this paper to the literature

- The results of this study contribute to the literature by providing information about problem-based learning classes.
- This meta-analysis provides current information for researchers, teachers, and other educators to see the results of the findings of the all-related individual studies' findings as a whole.
- The study includes foreign and domestic studies to more broadly obtain a comprehensive meta-analysis and a clear judgment on the effect of problem-based learning on students' attitudes, with mediator variables different from those of related meta-analysis studies in the literature.

Attitude is defined as tendencies of feelings and behaviors toward objects or subjects that include psychological values; they indirectly exist in an individual's life and stem from an individual's observable behaviors (Ilgaz, 2006; Tolan, 1985). In the teaching–learning process, a positive attitude toward courses is regarded as an important feature of the affective domain, and students should adopt this attitude. For example, students who have just started attending school have no direct experience about schools and learning in schools. Therefore, in the first phases of the teaching–learning process, they do not have a positive or negative attitude toward schools. Nevertheless, if a child has a perception of success in a school in the early years and if he establishes generally positive relationships with teachers or other students, his attitude toward the school will be positive. Conversely, if a child fails his or her courses in the first year, then she might have a negative attitude toward a school. Bloom (1956) indicated that such children have negative attitudes toward school, and they perceive school as a bad place. Thus, the significance of attitudes toward schools on student achievement has been studied.

As the effects on achievement of students' attitudes toward courses has been verified, the application of different teaching–learning approaches has become a significant area of study in the literature, in terms of whether these approaches positively affect students' attitudes. Problem-based learning (PBL) is one such approach and emphasizes the significance of affective properties of students as well as cognitive and psychomotor properties in order to accomplish student achievement. PBL has an integrative structure as it includes cognitive, affective, and psychomotor learning in the teaching–learning process (Walton & Matthews, 1989).

The aim of the study is to determine the effects of PBL on students' attitudes toward courses according to traditional teaching. With regards to this, the research question is determined as "Do the research findings concerning PBL's effects on student attitude toward courses as compared to traditional teaching have significant differences in support of PBL while effect sizes are considered?" In addition, the study aims to find out whether the effects of PBL on attitude changes according to the status of study, scientific field of the application, education level of students, sample size, and application time. In order to answer these main question and sub-questions, the method of meta-analysis has been employed.

Problem-based learning approach

PBL is a student-oriented approach that requires students to do research, combine theory and practice, find practical solutions over a defined problem, and use their knowledge and skills (Savery, 2006). Similarly, Barrows (2002) explains PBL as an approach that allows students to gain effective skills for problem-solving through different research and experiences in the education field and to accumulate knowledge through learning, team work, different subjects and disciplines. Edens (2000) emphasizes that the PBL approach teaches students how to think and it encourages them to do research. In addition, Johnstone and Biggs (1998) indicate that PBL is a student-oriented approach; it gives problem solving skills to students in addition to teaching basic knowledge consisting of real situations.

In PBL, students do not only learn the subject, but they acquire skills of transferring the knowledge, taking responsibility for their own learning and life-long learning (Tseng, Chiang & Hsu, 2008). Thus, according to Arends (1998), the purpose of this approach is, after significant research by students, to reach the very essence of the subject and therefore gain knowledge for the long term and transfer it to different fields. In addition to these skills, students develop their thinking capacities, acquire skills of communication, and create a team and work with it (Mierson & Parikh, 2000). Kaptan and Korkmaz (2001) emphasize the effect of PBL on attitudes, such as learning interests and curiosity. It has been indicated that PBL is effective in terms of developing students' affective properties, such as attitude toward courses, desire and motivation, making knowledge permanent, and acquiring skills like problem solving, gathering knowledge, and doing research (Kaufman & Mann, 1997; Sifoğlu, 2007).

PBL, which is regarded as an active learning approach, plays a significant role in increasing students' level of interest and achievement (Delisle, 1997). PBL applications teach students how to work as a team (Uden, 2006) and help to determine high-level cognitive skills such as analysis, synthesis, and assessment, which are necessary for problem solving in the process. It also contributes to the development of skills like thinking and establishing cause–effect relationships (House, 2000; Saban, 2004). This approach, which allows students to work actively as teams on a predefined problem, provides opportunities for students to develop their critical thinking skills (Hastings, 2003). PBL's application in the teaching–learning process helps students to understand and interpret knowledge deeply, to configure knowledge, to achieve internal motivations, and to become rational individuals (Beringer, 2007; Dooley, 1997; Duch, Groh & Alen, 2001; Hmelo-Silver, 2004).

PBL was introduced at the end of the 1960s by McMaster University Medical School in Canada, as a teaching and learning approach, and was included in the literature. In the 1970s, it was applied in several medical schools. The number of schools that adapted PBL increases every year. Applications in the field of medicine are followed by applications in several disciplines and fields such as social sciences, engineering, architecture, management, law, economics, administration, mathematics, natural sciences, agriculture etc. PBL application is established in

schools and its importance in the teaching–learning process has been considered (Schwarts, Mennin & Webb, 2001).

Research focus

From the 20th century to today, PBL has never lost its importance in the teaching–learning process. Several recent studies continuously investigated PBL's effects on student performance (achievement and skills), student and teacher satisfaction and student attitude toward courses (Albanese & Mitchell, 1993; Leary, 2012; Walker & Leary, 2009). Today, the rise of PBL continues, and this trend encourages researchers to undertake studies for determining the effectiveness of this approach. Due to an increasing recognition of the importance of affective domain, several independent studies have investigated PBL's effects on students' attitudes toward courses (Altunçekiç, 2010; Çelik, Eroğlu & Selvi, 2012; Günhan & Başer, 2008; Kuşdemir, 2010). However, different conclusions have been reached from these studies. In some studies, scholars argue that PBL has positive effects on attitude (Abdullah & Tarmizi, 2010; Marum, 2009; Tandoğan, 2006; Tavukçu, 2006), whereas some identified that PBL has no effects or negative effects (Koçakoğlu, 2008; Özdil, 2011; Reynolds & Hancock, 2010; Sevening & Baron, 2003). Different findings of these studies prevent a clear conclusion about the subject. Therefore, it might be said it needs a meta-analysis, which covers all independent studies on the above-mentioned subject and gives more generalizable and clear findings in comparison to individual studies (Cook et al., 1992).

In the literature, it has been found that meta-analysis studies investigating PBL's effects on student attitude toward courses as compared to traditional teaching have been mostly done in the field of health sciences, have included very few Turkish sources, and are not up to date (Colliver, 2000; Lewis & Tamblyn, 1987; Strobel & Barneveld, 2009). For instance, Leary's meta-analysis study compares traditional lecturing approach and PBL's effectiveness that is supported by self-regulative learning strategies (Leary, 2012). Leary found that PBL is effective in providing individual freedom during learning, so that students might develop learning abilities on their own. Leary also emphasized that PBL is effective on students in terms of development of their learning and affective skills.

When looking at related meta-analysis studies conducted in Turkey, it has been seen that these studies in particular have included a few studies conducted in foreign countries (Batdı, 2014; Üstün, 2012). In Üstün's (2012) doctoral thesis work (to determine the effect of PBL on students' attitudes in science classes (biology, physics, chemistry etc.) when compared to traditional teaching), at total of 23 studies, of which 20 were domestic (conducted in Turkey) and three were from abroad, were included in their meta-analysis. Batdı (2014) included the studies comparing PBL and traditional teaching in terms of students' attitudes toward courses in 2006–2013; however, foreign sources are omitted. Only 25 studies conducted in Turkey, mainly thesis works, are included in the study's meta-analysis. However, analyzing only unpublished works' findings, such as master's and doctoral theses in meta-analysis can be caused by a publication bias problem (Borenstein, Hedges, Higgins & Rothstein, 2009). The resistance of the meta-analysis versus the publication bias should have been calculated in Batdı's study (2014) to prove the validity of his meta-analysis.

As a result, in the present study, it has been expected that the meta-analysis, which aims to assess the impact of PBL on students' attitudes toward courses as compared to traditional teaching in different scientific fields (generally in science, mathematics, and social sciences) and includes foreign and domestic studies, provides a more comprehensive meta-analysis and a clear judgment on PBL's effect on students' attitudes.

METHODOLOGY

Method of the study

In this study, the meta-analysis method was employed. This method aims to combine statistical analysis of the quantitative finding of independent and similar studies and the results of the studies in a coherent and consistent way (Cohen, 1988). In a single experiment, raw data generally consist of the individual answers of the participants, whereas in meta-analysis raw data consist of the results of separate experiments (Radin & Ferrari, 1991). Therefore, meta-analysis is defined as statistical analyses that are used for combining, synthesizing, and interpreting experimental findings of independent studies (Wolf, 1986). Through this method, the findings of the studies are converted into a common measurement unit and compared; so their effect sizes are calculated by statistics (Rudy, 2001).

Meta-analysis aims to combine several analyzed results of individual studies and therefore, to obtain more generalizable knowledge of the subject (Glass, 1976; Hedges & Olkin, 1985). This method offers qualitative techniques to combine research findings of several types such as experimental studies, semi-experimental studies, and regression analyses; through the combination of results, researchers can reach common conclusions (Abramson, 1994; Sağlam & Yüksel, 2007). Meta-analysis can be employed for the results of experimental studies and qualitative data-oriented descriptive studies; however, in some types of studies meta-analysis cannot be conducted. Among these are theoretical studies, case studies, and ethical studies. In addition, a meta-analysis method can be used for re-analyzing statistical results given on research reports (Wilson, Lipsey & Derzon, 2003).

The meta-analysis method has been criticized for its weak points: it might contain biased studies; it can neglect negative results as mostly positive results are published; and it tries to combine heterogeneous data. Meta-analysis studies might be deficient in terms of the number of studies included in meta-analysis to achieve the true effect size level; or only meaningful results might be included. In addition, it would be more difficult to reach unpublished studies, and researchers may have to include more published studies in their meta-analysis. Because of a high probability of getting significant results from published studies, a criticism had been broached that meta-analysis studies might be included biased studies. This criticism is called "publication bias" and it needs to be proven that meta-analysis studies do not include any biased studies (Borenstein et al., 2009). However, these criticisms might stem from mostly methodologically ill-executed meta-analysis studies. Such critics can be refuted through detailed explanations concerning how the analysis has been conducted during meta-analysis and through verification of independent analysts. Also, all studies (not only studies that reached significant findings) should be considered in the analysis. In this way, prejudgments of meta-analysis can be prevented. A good meta-analysis also covers unpublished works (De Coster, 2004; Radin & Ferrari, 1991). In addition, the probability of overgeneralization in meta-analysis is not more than in other types of survey (De Coster, 2004). Glass, McGaw, and Smith (1981) claim that criticisms concerning heterogeneity can be overcome through coding of independent variables of meta-analyzed studies. For example, independent variables of studies such as gender of subjects or different applied techniques can be coded and analyzed, so that their connection with meta-analysis results can be understood. In this context, a pattern meticulously investigating the source of heterogeneity between meta-analyzed studies is regarded an effective way to check validity and credibility of a meta-analysis study (Ergene, 1999). Consequently, a well-executed meta-analysis study counterpoises these critics.

Effect size

The basic unit of meta-analysis studies is the effect size. Pigott (2012) talks about three basic types of effect size: (i) The standardized mean difference; (ii) The correlation coefficient; (iii) The log odds ratio.

If the same scale is used in all meta-analyzed studies, non-standardized raw mean difference can be used as effect size. However, like in this study, if different scales are used in studies in order to reach findings, effect sizes of each study should be standardized. In this case, standardized mean difference is used for effect size (d or g) (Pigott, 2012). In small samples, there is a tendency to show d's accurate value more than usual. This situation causes d to be biased. In order to eliminate this bias and make standardized mean difference neutral, d should be converted into Hedges g. This transformation operation is formulated as $g = c \times d = c(d)$. Standardized mean difference effect size (d) can be achieved through this formula (Pigott, 2012):

$d = c(d).[(X - Y)/Sp^2]$

$Sp^2 = (nx - 1)sx2 + (ny - 1)sy^2/(nx - 1) + (ny - 1)$

$c(d) = g = 1 - [3/(4(nx + ny) - 9)]$

$Vd = [nx + ny/nxny] + [d2/2(nx + ny)]$

$SEd = \sqrt{Vd}$

In this formula, X and Y refer to the mean differences of two groups, Sx and Sy refer to their standard deviation, Sp refer to pooled standard deviation in groups, and nx and ny refer to sample sizes of the groups. (Vd) formula is developed to determine d's variance and c(d) formula is developed to eliminate a bias-oriented small sample size. Standard error (SEd) of the standardized mean difference is the mean square of d's variance.

In general, standardized mean difference is determined by dividing difference between two groups' mean difference by total standard deviation (Durlak, 1995). If these two groups are formed by the researcher as experiment and control groups, this comparative analysis is called treatment effectiveness meta-analysis; if it is a natural classification (e.g., male and female groups), it is called group differences meta-analysis (Durlak, 1995).

In addition to standardized mean difference effect size, if studies report correlation data, then correlation coefficients are generally used as effect sizes in meta-analysis studies (Borenstein, Hedges, Higgins & Rothstein, 2013). Also, log odds ratio, which is calculated to compare assumption ratios of two groups, is used as effect size in meta-analysis studies (Pigott, 2012).

While the interpretation of calculated effect size is considered, according to Cohen (1988) if the study's effect size value is (i) 0.20 and less, then there is a low-level effect, (ii) between 0.20 and 0.80, then there is a medium-level effect; (iii) 0.80 and over, then there is high-level effect. In this meta-analysis study, Cohen's classification has been used to interpret effect size values.

Types of meta-analysis model

After calculation of meta-analyzed studies' effect size, these values are combined in accordance with the convenient meta-analysis model. In meta-analysis studies, two meta-analysis models are commonly used: fixed effects model and random effects model. According to Wolf (1986), if effect sizes of a series of independent studies are statistically significant (homogenous), then these studies test the same hypothesis. In this case, a fixed effects model should be selected for meta-analysis. Fixed effects model is based on the assumption that real effect size is shared by all meta-analyzed studies and that factors that can chance effect size are same in all studies (Borenstein et al., 2013). However, effect sizes of independent studies are heterogeneous so random effects models should be preferred in meta-analysis study. In the random effects model, the real effect size of all studies is assumed different—in other words,

heterogeneous (Field, 2001). For example, let us assume that in the field of health sciences a researcher investigates the effects of a medicine on patients. It is likely that experiments include the same measurement scale and that they are applied in the same conditions. Therefore, it is possible that the effect sizes of these studies after meta-analysis are close, and this situation shows that effect sizes of these studies are homogenously distributed (fixed effects model). Conversely, in the field of social sciences, even with independent studies analyzing the same subject—in terms of many perspectives such as measurement scale, sample group, and executors of the experiment etc.—it is unlikely that the effect sizes of the studies are close. This situation shows that effect sizes of these studies are heterogeneously distributed (random effects model). In meta-analysis studies, meta-analysis models are selected according to the homogenous or heterogeneous distribution. According to heterogeneity tests of the study, a statistically significant difference among effect sizes of studies included in meta-analysis has been found. In other words, these values are heterogeneously distributed. Therefore, in this study random effects model has been used in order to calculate effect size.

Steps of meta-analysis

In the study, the steps of meta-analysis application have been followed, so the following process has been applied. (i) First of all, the research question of the study has been determined. (ii) After finalizing the research question, a compressive literature review has been launched and sufficient sources have been accessed in domestic and foreign studies for meta-analysis. (iii) The meet criteria for meta-analysis of the study have been specified: the purpose of the study is determined as clearly finding out PBL's effect on students' attitudes toward courses when compared to traditional teaching. The study should have an experimental design with a control group. The research report should include statistical information needed to calculate the effect size. (iv) Among accessible sources, studies that meet criteria for meta-analysis have been included in the meta-analysis. (v) The coding forms from the previous meta-analysis studies have been examined, and based on findings of studies about factors affecting PBL approach, mediator variables have been determined. So, the coding form of the present study has been developed. (vi) The studies included in the meta-analysis have been coded through the coding form by researchers. (vii) In order to calculate the effect size index of the included studies, the treatment effectiveness meta-analysis method has been used as a meta-analysis type. In order to calculate effect size of these studies, frequency, standard deviation, and arithmetic mean values or values derived from test statistics of the research findings have been used. (viii) In order to combine effect sizes of the studies, a random effects model, which is used when studies are heterogeneous, has been applied. Analyses have been made with the help of the CMA (comprehensive meta-analysis) program. (viv) In the final stage of the study, research findings obtained after the method applied, have been interpreted and turned into a report.

Data collection

In the study, meta-analysis application steps were followed, and firstly, the research question was determined. Then, in order to determine whether this research question was enough for a meta-analysis study, an extensive literature review was done. The researcher scanned the available electronic catalogues in the libraries of the universities: among which the reference indexes and databases, Science Citation Index, Social Science Citation Index, Arts and Humanities Citation Index, ERIC (Educational Resources Information Center), Proquest Digital Dissertations have been scanned. Moreover, the Google Scholar search engine and ULAKBIM National Combined Catalogue service were consulted. In addition, conference and congress

proceedings books were scanned. During electronic scans, expressions such as "problem-based learning," "traditional teaching," "meta-analysis," and "the effects of problem-based learning on students' attitudes" and their equivalents in Turkish have been written both with and without quotations. The references of the studies have been also examined and through this method new sources have been accessed. In this purpose, the study included master's theses, doctorate theses undertaken in Turkey and foreign countries, articles published in domestic and international scientific journals, articles that were obtained from international databases, and conference proceedings.

After an extensive literature review, 98 studies, which fit the aim of the study, were identified. Some of these studies, which do not fit the meet criteria of meta-analysis of the study, were eliminated. A study is not included in meta-analysis if it is not in the scope of research or it lacks necessary statistical data for meta-analysis (Wilson et al., 2003). Consequently, the research findings of 47 studies were used in the meta-analysis. The distribution of meta-analyzed studies with regard to years were identified between 1997 and 2015. Most studies were done in 2007 (7 studies), 2008 (5 studies), 2009 (6 studies), and 2010 (7 studies). For the following years, a decrease in number of related studies was found (in years 2011, 2 studies; 2012, 5 studies; 2013, 4 studies; 2014, 1 study; 2015, for first five months, no study). All of the studies included in the meta-analysis had an experimental design with control groups and aimed to determine the effect of PBL on students' attitudes toward courses when compared to traditional teaching. A PBL approach was applied in experimental groups of the studies. In control groups, traditional teaching was performed. In these studies, traditional learning approach was defined as a lecture-based, teacher-oriented approach in which students take notes as listeners.

Validity and reliability study of the coding process

Coding form is used to convert information to numerical data via coding during the coding process of the meta-analysis. This information includes; publication year, publication status, education level of the group, application time, sample size, and subject field.

In order to obtain reliability of the coding process, three specialist educational sciences researchers were employed, and coded 10 randomly selected studies among the meta-analyzed studies. After coding, they found reliability coefficients between raters of 0.91. This value indicated that the coding process is reliable (Ergene, 1999; Leary, 2012).

Data analysis

In this study, each meta-analyzed study's effect size values and combined effect size were calculated with the assistance of Comprehensive Meta-Analysis (CMA) Software v2.0. The CMA software calculates effect size by using reported findings of the studies that are included in meta-analysis. In order to determine whether each study tests the same hypothesis or not, a heterogeneity test was done with the help of the CMA software. A heterogeneity test is used in order to determine if there is a significant difference among effect sizes of studies included in a meta-analysis. According to the heterogeneity test, the significant difference among effect sizes of studies in meta-analysis meant that the distribution of effect sizes is not similar, it is heterogeneity. Moreover, it was specified whether there was a significant difference among the effect sizes of studies included in the meta-analysis according to the mediator variables by the heterogeneity tests.

In order to reveal the publication bias of the study, the heterogeneity test, funnel graphic, and Begg and Mazumdar rank correlation test were used. The resistance of the meta-analysis study versus the publication bias was also calculated with Classic

Fail-Safe N analysis. In addition, data input of the coding form was done through the Microsoft Excel 2007 software.

RESULTS

Research findings concerning the first sub-question of the study

In the study, in order to answer the sub-question "What are the effects of PBL on student attitude toward courses when compared to traditional teaching?" effect sizes of 47 meta-analyzed studies were calculated. Table 1 indicates heterogeneous distribution values, average effect size, and confidence intervals of these studies in accordance with the effect model.

Table 1. Average effect size and maximum and minimum values of confidence interval

Model	N	Hedges's g	95% Confidence Interval		Q-between classes effect	P
			Lower	Upper		
Fixed Effects Model	47	0.37	0.30	0.43	235.45	0.00
Random Effects Model	47	0.44	0.28	0.60		

In the study, a heterogeneity test was applied to determine the meta-analysis model of the study. The heterogeneity test results ($Q = 235.45$; $p < 0.05$) showed that effect size distribution was heterogeneous and indicated that the meta-analysis model of the study fitted to the random effects model. According to the random effects model, the 95% confidence interval's limit superior was 0.60, and its limit inferior was 0.28. Average value of effect sizes was calculated at 0.44. These findings were interpreted in the light of Cohen's (1988) framework and it was found that PBL had positive effects in terms of increasing students' attitudes toward courses as compared to traditional teaching, but this effect is low-level. Forest graph showing the distribution of effect sizes of the studies included in the meta-analysis has been also shown in Figure 1.

As seen in Table 1 and Figure 1, in order to verify that PBL's effects on student attitude toward courses is low ($g = 0.44$), Classic Fail-Safe N analysis was applied. The results of this analysis are given in Table 2.

According to Classic Fail-Safe N analysis given on Table 2, it has been determined that the meta-analysis was valid and resistant versus the publication bias. 1508 more studies are needed to invalidate results of the meta-analysis study ($p<0.05$).

Research findings concerning the second sub-question of the study

The results of the analysis concerning the sub-question "Is there a significant difference between effect sizes of published and unpublished studies which included in the meta-analysis?" are presented in Table 3.

This meta-analysis covers eight doctorate theses, 18 master's theses, and 21 articles published in peer-reviewed journals, which investigated PBL's effects on student attitude toward courses when compared to traditional teaching. As seen in Table 3, the average effect size (Hedges's g) of the published studies was 0.42 in accordance with the random effects model. Moreover, this value was found to be 0.45 for unpublished studies. According to the result of the heterogeneity test, no significant difference was specified between effect sizes of published and unpublished studies ($Q = 0.03$; $p > 0.05$). In this case, it can be said that there was no publication bias in the meta-analysis. In addition to publication bias analysis, funnel graphic was formed on Figure 2, to give addition information about the matter.

Figure 2 shows distribution of the studies that are included in the meta-analysis. Symmetrical distribution on the graphic verifies that there was no publication bias in

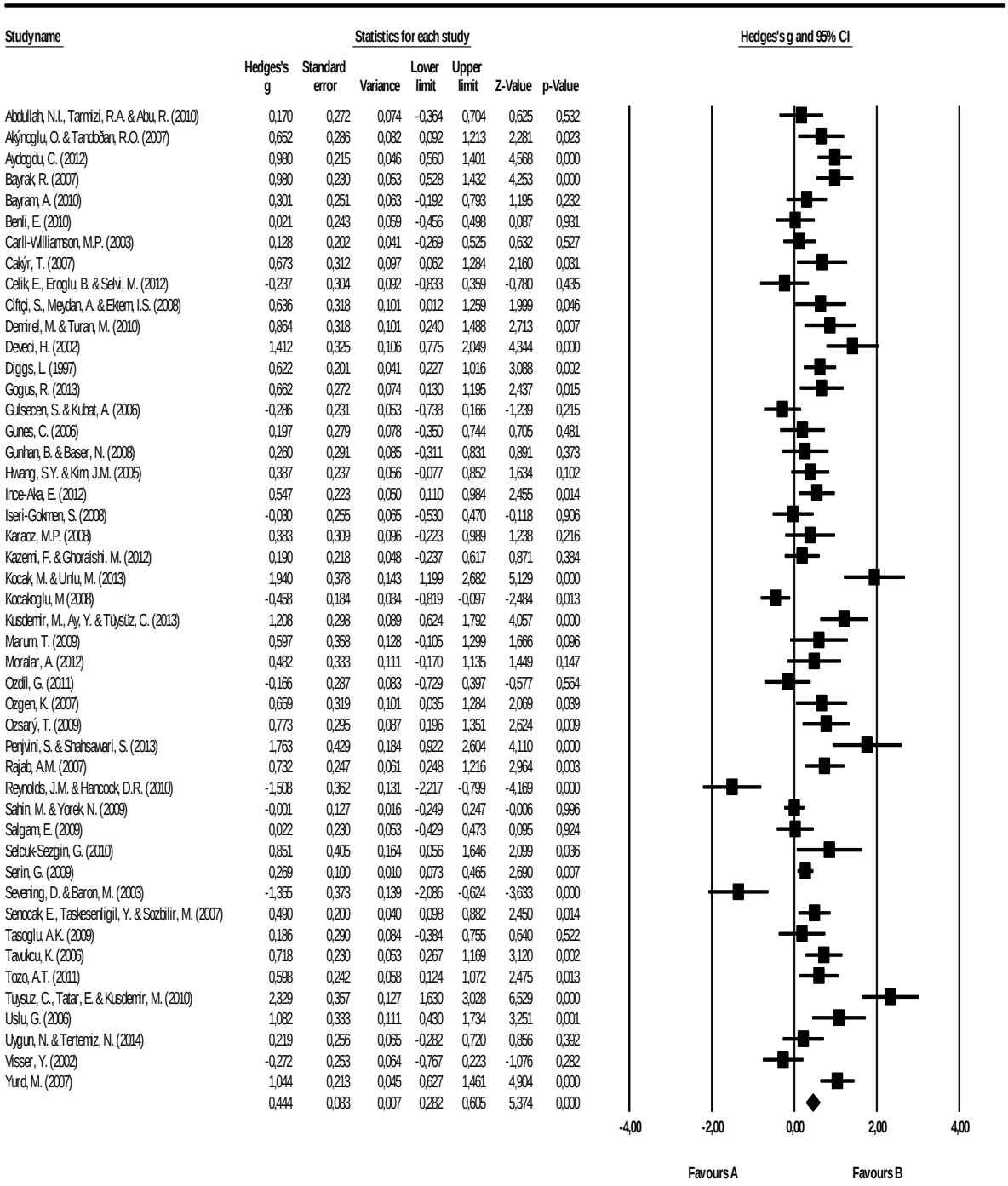

Figure 1. Forest graph showing the distribution of effect sizes of the studies included in the meta-analysis

meta-analyzed studies on behalf of PBL. In situations when there is publication bias, asymmetrical and skew distribution is expected on the graphic (Üstün & Eryılmaz, 2014). In addition to the funnel graphic, a Begg and Mazumdar rank correlation test was employed. This test indicated that the study's sample was not statistically biased. Results of the analysis obtained from the test are presented in Table 4.

According to these findings, they once more prove that meta-analyzed studies are not biased (tau = 0.18, p > 0.05).

Table 2. Classic fail-safe N

The Resistance of the Meta-Analysis versus Publication Bias	
Z-value	11.27
p-value	0.00
Alpha value	0.05
Alpha value for the Z-value	1.95
N	47
p>the number of missing studies for the alpha result	1508

Table 3. Difference of effect sizes according to the publication status (publication bias analysis results)

Model	**N**	**Hedges's g**	**95% Confidence Interval**		**Heterogeneity test**	
Random Effects Model			**Lower**	**Upper**	**Q-value**	**P**
Unpublished	26	0.45	0.29	0.62		
Published	21	0.42	0.10	0.74		
TotalBetween*					0.03	0.85

** How accurate is the publication status variable in explaining total variance*

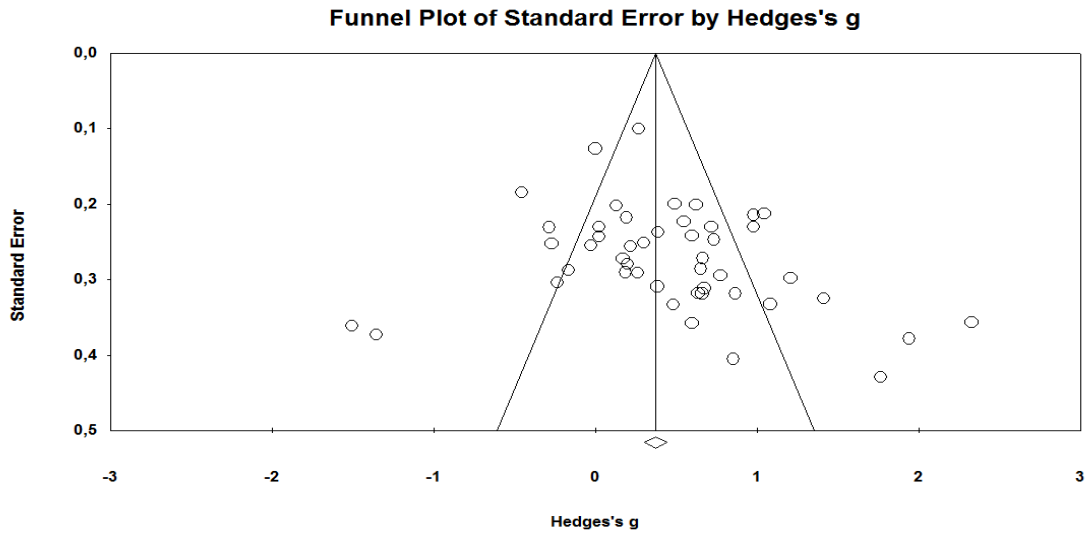

Figure 2. Funnel graphic showing publication bias status in meta-analysed studies

Table 4. Publication bias status of sampled studies

Publication Bias	
Kendall's S (P-Q)	205.00
Kendall's tau	0.18
Tau for z-value	1.87
P	0.06

Research findings concerning the third sub-question of the study

In order to reach research findings concerning the sub-question "Is there a significant difference between effect sizes of studies according to their sample sizes ?," an analysis has been made. The results of this analysis are given in Table 5.

Sample sizes of PBL applications of meta-analyzed studies were examined. Accordingly, minimum sample size groups included 12 individuals, and the maximum sample size groups contained 100 individuals. Frequency distributions of studies concerning their sample size were considered in classification. As seen in Table 5, the average effect size of experiment groups with 12–22 persons was 0.45. This value was calculated at 0.52 for groups consisting of 23–33 persons, 0.43 for groups consisting of 34–44 persons, and 0.34 for groups of more than 45 persons. Heterogeneity test results indicated that there was no significant difference between groups in terms of

their effect sizes (Q = 0.78, p > 0.05). With regard to this finding, it may be said that sample sizes of PBL groups in experimental treatments is not one of the factors affecting student attitude.

Research findings concerning the fourth sub-question of the study

Table 6 presents the results of the analysis concerning another sub-question of the study: "Is there a significant difference between effect sizes of studies according to the scientific field."

It has been specified that the most studies that determine the effect of PBL on students' attitudes as compared to traditional teaching, have been done in the field of science. As indicated in Table 6, effect sizes according to different scientific field in terms of random effects models are as follows: science 0.44, mathematics 0.28, and social sciences 0.68. A heterogeneity test was applied in order to find whether there was a significant difference between effect sizes concerning the scientific fields where PBL has been used. As a result, it was determined that there was not a significant difference between average effect sizes of the studies in terms of the scientific field of the applications (Q = 1.43; p > 0.05). Research findings demonstrated that the scientific field where PBL applied is not among the factors affecting students' attitude.

Research findings concerning the fifth sub-question of the study

In the study, results of the analysis done in order to acquire findings concerning the question "is there a significant difference between effect sizes of the studies according to the education levels of the students where PBL has been applied" are presented in Table 7.

As indicated in Table 7, in accordance with the random effects model, average effect size value with regard to student attitude toward courses was found to be 0.73 for elementary school level, 0.21 for middle school level, 0.69 for high school level,

Table 5. Effect size differences according to the sample size

Model	N	Hedges's g	%95 Confidence Interval		Heterogeneity test	
Random Effects Model			Lower	Upper	Q-value	P
12-22 individuals	13	0.45	-0.05	0.96		
23-33 individuals	16	0.52	0.22	0.81		
34-44 individuals	8	0.43	0.19	0.67		
45 and more	10	0.34	0.05	0.62		
Total Between*					0.78	0.85

** How accurate is the sample size variable in explaining total variance*

Table 6. Effect size differences according to the scientific field

Model	N	Hedges's g	%95 Confidence Interval		Heterogeneity test	
Random Effects Model			Lower	Upper	Q-value	p
Science	31	0.44	0.25	0.63		
Mathematics	10	0.28	-0.01	0.56		
Social Sciences	6	0.68	-0.09	1.46		
Total Between*					1.43	0.48

** How accurate is the scientific field variable in explaining total variance*

Table 7. Effect size differences according to education levels

Model	N	Hedges's g	%95 Güven Aralığı		Heterojenlik testi	
Random Effects Model			Alt Sınır	Üst Sınır	Q-değeri	P
Elementary School	5	0.73	0.30	1.15		
Middle School	16	0.21	-0.07	0.50		
High School	13	0.69	0.42	1.09		
Bachelor's Degree	13	0.38	0.20	0.56		
*Total Between**					*5.86*	*0.11*

** How accurate is the education level variable in explaining total variance*

and 0.38 for bachelor's degree level. A heterogeneity test was been applied in order to find whether there was a significant difference between effect sizes of the meta-analyzed studies according to education level. This test results indicated that there was not a significant difference between effect sizes of the studies ($Q = 5.86$; $p > 0.05$). From the findings, it may be said that the effect of PBL on students' attitudes toward courses when compared to traditional teaching does not vary according to education levels.

Research findings concerning the sixth sub-question of the study

Table 8 presents the results of the analysis in order to answer another research question of the study: "Is there a significant difference between effect sizes of the studies with regard to the PBL's application time?"

Table 8. Effect size differences according to application time (hour)

Model	N	Hedges's g	%95 Confidence Interval		Heterogenety test	
Random Effects Model			Lower	Upper	Q-value	P
1-8 h.	4	0.80	-0.04	1.65		
9-16 h.	12	0.55	0.19	0.91		
17-23 h.	9	0.42	0.08	0.76		
24-32 h.	10	0.24	-0.05	0.55		
33 h and more	12	0.41	0.06	0.76		
Total Between*					2.55	0.63

** How accurate is the application time variable in explaining total variance*

PBL application times of the meta-analyzed studies are examined. Accordingly, it was identified that applications lasted for a minimum of 4 hours and a maximum of one semester. In studies it was observed that application durations were 4 hours per week on average. Classification was made in accordance with applications that lasted 2 weeks, 4 weeks, 6 weeks, 8 weeks, and more. As seen in Table 8, in accordance with the random effects model, effect size was found to be 0.80 for the applications that lasted 1–8 hours; 0.55 for applications that lasted 9–16 hours, 0.42 for applications that lasted 17–23 hours, 0.24 for applications that lasted 24–32 hours, and 0.41 for applications whose duration is over 45 hours. A heterogeneity test was been applied in order to find whether there was a significant difference between effect sizes of the meta-analyzed studies according to application time per hour. The test results show that there was no significant difference between effect sizes of the studies ($Q = 2.55$; $p > 0.05$). Accordingly, the effects of PBL on attitude as compared to traditional teaching did not change according to application time, long or short.

DISCUSSION AND CONCLUSIONS

From past to present, the effects of PBL on student attitude toward courses when compared to traditional teaching were analyzed by several different researchers (Abdullah & Tarmizi, 2010; Günhan & Başer, 2008; Marum, 2009; Reynolds & Hancock, 2010; Tandoğan, 2006). According to the results of these studies, generally students had positive attitudes toward PBL, and consequently, their interests toward courses and their attendance rates increase in PBL classes (Alper, Öztürk & Akyol, 2014). However, in the literature, as well as some studies which argue that PBL has a positive effect (Diggs, 1997; Kuşdemir, 2013; Yurd, 2007); some argue that PBL has a negative effect or no effect positively or negatively on students' attitudes as compared to traditional teaching (Özdil, 2011; Reynolds & Hancock, 2010). So, it seems that individual studies investigating PBL's effects on student attitude toward courses when compared to traditional teaching did not agree on a clear result. Therefore, a meta-analysis study, which aims to combine results of such studies, has gained importance.

According to research findings of this meta-analysis study, PBL's effects on student attitude are positive but low (g = 0.44) according to the random effects model. When looking at the meta-analysis studies related to this subject, it has been seen that the PBL approach is more effective on students' attitudes toward courses than traditional teaching (Colliver, 2000; Leary, 2012; Üstün, 2012). Üstün (2012) did a meta-analysis study to compare the effects of PBL and traditional teaching in terms of students' attitudes in science classes: PBL has a medium effect on students' attitudes toward science classes when compared to traditional teaching. Similarly, Batdı's (2014) study reported a medium effect between PBL and students' attitudes toward courses. In the present study, due to the analyses of publication bias and resistance of meta-analysis, the analyses confirmed that PBL's effects on attitude are low and discovering the factors behind this result has gained importance. In order to determine factors, previous studies that investigate the effectiveness of PBL have been examined, and factors that affect the approach according to previous studies have been listed (Kaufman & Mann, 1997; Leary, 2012; Walker & Leary, 2009). Dochy, Segers, Van den Bossche and Gijbels (2003) did a meta-analysis of studies that examine the effects of PBL in order to determine the factors influencing a PBL approach in their study, which are listed as follows: factors related to research method, education levels of students, sample size, field of science, application time, and assessment types. In addition, previous meta-analysis studies and coding forms of these studies have been examined (Acar, 2011; Ergene, 1999; Topçu, 2009). As a result, the factors that may influence PBL on students' attitudes toward courses are specified as publication status, sample size, field of science, education level, and application time. These factors are assigned to the study as mediator variables.

In terms of mediators, at first, the results of the analyses indicate that the sample size of experimental groups applying PBL had no effect on students' attitudes toward courses when compared to traditional teaching. In other words, sample size (big or small) does not change the effects of a PBL approach on students' attitudes. He findings of studies investigating PBL's sample size also support this and it is emphasized that PBL can be applied through groups when the group has a large sample or individual studies when the group has a small sample (Uden, 2006). Moreover, in the literature, when looking at individual studies that applied PBL, it is seen that in some studies implementations of PBL has been done in groups (Aydoğdu, 2012; Oskay-Özyalçın, Erdem & Yılmaz, 2009), and in others as an individual (Kuşdemir & Ünlü, 2013; Luck & Norton, 2004). PBL implementation in students' individual or group work does not cause a change in students' attitude toward courses (Serin, 2009). Serin (2009) investigated the effects of PBL on students' achievements, science process skills, and attitudes toward science classes. He formed two experimental groups, in one a PBL approach has been applied in groups, in another the application has been carried out with individuals. In the study's control group, it is stated that traditional teaching was done. According to the findings obtained after five weeks application, there was no significant difference between experimental groups in terms of students' attitudes toward courses. As a result, the students' working individually or in groups in PBL applications might not affect students' attitudes. On the other hand, Bridges (1992) stated that in PBL approach students who take responsibility as an individual or a group learned more in small group work. However, it is emphasized in related studies that PBL may be applied without any grouping, especially in small samples, with individual works (Robins, 2005). In this case, an application process should be planned by the teacher by considering the number of students in PBL groups, students' levels, cognitive and affective properties together with problem features, and solution duration. Consequently, even if PBL is applied in large samples, teachers can divide students into groups, and students can work in small groups.

According to another finding obtained from the study, it is determined that application time of PBL in experimental groups has no effect on students' attitudes toward courses when compared to traditional teaching. In other words, application time (short or long) does not change the effects of PBL on students' attitudes. This finding is also supported by Üstün's (2014) meta-analysis study. This study examines the effects of PBL on students' achievement, motivation, skills (problem solving, self-confidence, critical thinking, science process skills etc.), and students' attitudes in terms of some mediator variables. As a result, it has been seen, according to application time, that PBL has no effect on students' attitudes. Nevertheless, Strobel and Barneveld (2009) reached different findings. They did a meta-analysis study which analyzed previously meta-analysis studies of PBL. They compared the findings of eight meta-analysis studies in terms of PBL's application duration (long- or short-term) and found that PBL is more effective in long-term applications compared to traditional approaches. In addition, Schultz-Ross and Kline (1999) urged that students should adapt the PBL approach in order to acquire positive results from PBL applications. They emphasized that students need approximately 6 months of learning time (as cited in, Yadav, Subedi, Lundeberg & Bunting, 2011). Previous research on this topic demonstrates that the relationship between affective properties and achievement showed a little change in a particular academic year; when affective characteristics grow with a few years' experience on a course and affective properties toward a course change insignificantly (Bloom, 1956). This result indicates that student interest and attitude resist change; therefore, short-term applications may not influence student attitude toward courses. Nevertheless, according to the findings of the same study (Bloom, 1956), these fixed attitudes are directly proportional to achievement, and student achievement is generally stable between years. Therefore, when a student does not have a positive attitude toward a particular course, their achievement is directly affected. In addition, students feel that they are weak in terms of cognitive and affective properties; because, as the reason for the failure of the student, it has been shown that they had negative attitudes toward courses. So, if a student feels successful in a class through an applied teaching–learning approach, it cannot be said that their negative attitude (if any) never changes. In this perspective, studies found that PBL positively affects student achievement (Chang, 2001; Kuşdemir, 2010; Özgen & Pesen, 2008; Phan, 2008; Şendağ & Odabaşı, 2009) and indicate that this method can be effective on student attitude. On the other hand, in the literature, some studies indicate that long-term applications might result in a decrease in students' interests toward courses (Kocakaya, 2011). In order to prevent this, as students gain knowledge and skills about the subject, a change to the teaching–learning methods and techniques within the PBL approach is recommended (Kenn, 1996). Thus, to improve both cognitive and affective properties of students in PBL applications and to obtain effective results from these applications, students should recognize the approach before the PBL applications and have a background in the subject (Dağyar, 2014). It can be said that students who are aware of the PBL approach and have previous knowledge of it, are not influenced by application duration, whether long or short.

The study also analyzed PBL's effects on student attitude in terms of education level. The analysis revealed that effect sizes of PBL on student attitude do not vary according to education level. In other words, there is no difference among the effect sizes obtained from PBL's implementations conducted in elementary school, middle school, high school, and higher education levels. This finding is supported by Üstün's (2012) study which has been specified that PBL implementation in primary, secondary or higher education levels does not affect students' attitudes toward courses. On the other hand, Duman and Akbaş (2010) compared levels of attitudes of the first, second, third, and fourth grade students of a nursery school toward PBL.

Consequently, they found that fourth grade students' positive attitudes toward PBL were significantly higher than low-level students. The reason behind this is related to the adaptation and internalization of the PBL approach by senior students. Bloom (1956) emphasizes that higher level students, with deeper information about a particular course, possessed a better relationship between their affective properties about the course and their achievement than students at the lower education levels. For example, if a high school student has a positive attitude toward a course, this brings a self-confidence when he or she takes the same course later ("I am successful at this course so that I can be successful again") and positively contributes to his or situation.

The above-mentioned relationship between affective properties of students and their achievement is found to be high, because senior students in comparison to new students have more settled feeling of positive or negative attitude toward courses. If the teaching–learning process on education levels is not regulated to eliminate negative attitudes, these attitudes are retained. For this reason, in order to prevent negative attitudes toward courses, active learning approaches that enable students to be responsible for their own learning, such as the PBL approach, should be applied in the teaching–learning process. Thus, the PBL approach aims to create students who gradually become independent from teachers, continue to learn all along their lives, and gain positive attitudes toward learning (Kaptan & Korkmaz, 2001). Moreover, while the application steps of the PBL approach are examined, the approach seems to suit perfectly the students who have the ability for abstract thinking in order to reach results through systematical reasoning and oral-based hypothesis. Therefore, attitudes of primary and elementary school students toward courses can remain more negative than those of upper level students, because they might not totally adapt to the PBL approach. However, this situation must not be interpreted as PBL should not be applied in lower education levels; indeed, according to the findings obtained from the study, in terms of education levels there is not a significant difference among students' attitude levels. In short, at different education levels the effect size values obtained are close together.

Consequently, in classes of different education level, where PBL is applied, the teaching–learning process should be regulated in accordance with features of student development. Each education level has effects on the upper level. Teaching younger students in particular with the PBL approach will help students to adapt PBL to real life conditions. As students begin to use PBL principles in their real lives, they can build a PBL background for higher education levels. By this means, their negative attitudes toward courses will be changed, and they can reach an upper education level with more confidence regarding achievement.

The last finding of the study indicates that the effect size of PBL on student attitudes does not vary according to the scientific field where PBL is applied. Even if there is no difference among effect sizes of PBL on students' attitude, when distribution of scientific fields of the meta-analyzed studies are considered, very few studies have been done in other scientific fields except science. Üstün (2012) investigate whether the effect of PBL on students' attitude toward science courses, according to biology, physics, and chemistry areas which constitute the field of science, is varied or not. Accordingly, there is no significant difference among the science areas in terms of their effect sizes. In the present study, the studies that built on the field of science, social sciences, and mathematics have been also analyzed; however, it was determined that in terms of scientific field, the effect sizes of PBL on students' attitude when compared to traditional teaching do not differ. Therefore, there should be more studies on the effect of PBL on students' attitudes toward courses and the interest shown to science should also be dedicated to other fields. Walker and Leary (2009), in their PBL-oriented meta-analysis study, urged that more studies are particularly needed in social sciences and teacher training. Indeed, the

findings of the present study show that the studies in social sciences and mathematics are effective on students' attitudes toward courses at least as much as studies in science subjects.

In conclusion, students should firstly show interest in the subject or a course and should have positive attitudes in order to achieve success. For this positive attitude, learning approaches should be selected, planned, and executed correctly in the teaching–learning process. Only then can students be successful in courses and obtain positive attitudes toward learning throughout their lives. As a result of the study, it has been determined that the PBL approach is effective for students gaining positive attitude toward courses. Moreover, it has been specified that mediator variables, which are thought to change students' attitude levels in PBL applications, do not cause a significant difference on the effect size obtained. Therefore, it can be said that sample size, scientific field, education level, and application time in PBL implementations are not effective on students' attitudes toward courses.

The study is limited by the research conducted in Turkey and foreign countries, which aimed to investigate PBL effects on students' attitudes toward courses when compared to traditional teaching. These had an experimental design with a control group; in the experimental group PBL was used; in the control group traditional teaching was been applied. In addition, the research included in the meta-analysis is unpublished doctorates, master theses, proceedings, and published peer-reviewed articles, and they meet the criteria for meta-analysis of the study. In accordance with research findings, these theoretical and practical suggestions can be made: more studies investigating the effect of PBL on student attitude are needed in the fields of social sciences and mathematics; more research on young students is necessary so that individuals, who use PBL outside of the school and who can solve real life problems, can be raised. This study evaluated PBL's effectiveness only in terms of student attitude toward courses. For this reason, the study calls for more meta-analysis studies, particularly on studies which investigate the effectiveness of PBL in terms of different affective properties such as interest, motivation, concern, identity, and personality. It is particularly important to have more meta-analysis studies on education sciences, as in Turkey there are only a few meta-analysis studies in this field.

REFERENCES

Sign (+) refers to the studies included in the meta-analysis.

+Abdullah, N. I., Tarmizi, R. A. & Abu, R. (2010). The effects of problem based learning on mathematics performance and affective attributes in learning statistics at form four secondary level. Procedia Social and Behavioral Sciences, 8, 370–376. doi:10.1016/j.sbspro.2010.12.052.

Abramson J. H. (1994). Making sense of data: A self-instructional manual on the interpretation of epidemiological data. Oxford: Oxford University.

Acar, S. (2011). Testing the effects of students' attitude towards the lesson based on computer aided teaching in the field of physics chemistry biology and mathematics by the method of meta analysis. (Unpublished Master Thesis), Yuzuncu Yıl University, Turkey.

+Akınoğlu, O. & Tandoğan, R. O. (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. Retrieved from http://files.eric.ed.gov/fulltext/ED495669.pdf.

Albanese, M. & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. Academic Medicine, 68(1), 52-81. Retrieved from http://journals.lww.com/academicmedicine/Abstract/1993/01000/Problem based _Lear ning__A_Review_of_Literature_on.20.aspx.

Alper, A., Öztürk, S. & Akyol Aydın, C. (2014). Problem based learning studies in Turkey. Ankara University, Journal of Faculty of Educational Sciences, 47(1), 397-422. Retrieved from http://dergiler.ankara.edu.tr/dergiler/40/1917/20127.pdf.

Arends, R. I. (1998). Learning to teach. Boston, USA: McGrow Hill.

+Aydoğdu, C. (2012). The effect of problem based learning strategy in electrolysis and battery subject teaching. Hacettepe University Journal of Education 42, 48-59. Retrieved from http://www.efdergi.hacettepe.edu.tr/yonetim/icerik/makaleler/310-published.pdf.

Barrows, H. (2002). Is it truly possible to have such a thing as dPBL?. Distance Education, 23 (1), 119-122. doi:10.1080/01587910220124026.

Batdı, V. (2014). The effects of a problem based learning approach on students' attitude levels: A meta-analysis. Educational Research and Reviews, 9(9), 276-279. doi: 10.5897/ERR2014.1771.

+Bayrak, R. (2007). Teaching solids by problem based learning. (Unpublished Doctoral Thesis), Ataturk University, Turkey.

+Bayram, A. (2010). The effect of problem based learning on overcoming 5th grade students misconceptions about heat and temperature? (Unpublished Master Thesis), Selcuk University, Turkey.

+Benli, E. (2010). The research of the effects of problem based learning to the permanence of information, the academic success of science teacher candidates and their attitudes toward science. (Unpublished Master Thesis), Gazi University, Turkey.

Beringer, J. (2007). Application of problem based learning through research investigation. Journal of Geography in Higher Education, 31(3), 445-457. doi:10.1080/03098260701514033

Bloom, B. (1956). Bloom taxonomy of educational objectives: Book 1. New York: Longmans Green.

Borenstein, M., Hedges, L.V., Higgins, J.P.T. & Rothstein, H.R. (2013). Meta-analize giriş.[Introduction to meta-analysis]. (Serkan Dinçer). Anı: Ankara.

Borenstein, M., Hedges, L.V, Higgins, J.P.T. & Rothstein, H. R. (2009). Computing effect sizes for meta-analysis. Chichester: John Wiley and Sons.

+Carll-Williamson, M. P. (2003). The effect of problem-based learning in high school students enrolled in biology for the technologies as measured by concept of self and attitude toward science. (Unpublished Doctoral Thesis), University of South Carolina, Columbia.

Chang, C. (2001). Comparing the impacts of a problem-based computer-assisted instruction and the direct-interactive teaching method on student science achievement. Journal of Science Education and Technology, (2)10, 147-153. doi: 10.1023/A:1009469014218

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. US: Lawrence, Erlbaum.

Colliver, J. A. (2000). Effectiveness of problem-based learning curricula: Research and theory. Academic Medicine, 75(3), 259-266. doi: 10.1097/00001888-200003000-00017.

Cook, T. D., Cooper, H. M., Cordray, D.S., Hartmann, H., Hedges, L. V. Light, R. J., Louis, T. A. & Mosteller, F. (1992). Meta-analysis for explanation: A casebook. Newyork: Russell Sage.

+Çakır, T. (2007). The effect of problem-based learning method on students' achievement, retention and attitude in teaching the circle subjects that are in math course at seventh grade in elementary school. (Unpublished Master Thesis), Balıkesir University, Turkey.

+Çelik, E., Eroğlu, B. & Selvi, M. (2012). The effect of problem based learning approach in science education on students' academic achievement, and attitudes toward science and technology course. Kastamonu Education Journal, 20(1), 187-202. Retrieved from http://www.kefdergi.com/pdf/20_1/20_1_13.pdf.

+Çiftçi, S., Meydan, A. & Ektem, I.S. (2008). The effect of Problem-based Learning to the student's level of achievement and attitude. Selcuk University Journal of Institute of Social Sciences, 17, 179-190.

Dağyar, M. (2014). The effects of problem based learning on academic achievement: A meta-analysis study. (Unpublished Doctoral Thesis), Hacettepe University, Turkey.

De Coster, J. (2004). Meta-analysis notes. Retrieved from, www.stat-help.com/notes.

Delisle, R. (1997). Use problem-based learning in the classroom. USA: ASCD.

+Demirel, M. & Turan, M. (2010). The effects of problem based learning on achievement, attitude, metacognitive awareness and motivation. Hacettepe University Journal of Education, 38, 55-66. Retrieved from www.ulakbim.gov.tr.

Demirel, Ö. (1999). Öğretme sanatı. [The art of teaching]. Ankara: Pegema.

+Deveci, H. (2002). The effect of problem based learning to attitudes, success and retention in social studies. (Unpublished Doctoral Thesis), Anadolu University, Turkey.

+Diggs, L. (1997). Student attitude toward and achievement in science in a problem based learning educational experience. (Unpublished Doctoral Thesis), University of Missouri, Colombia.

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

Dooley, C. (1997). Problem-centered learning experiences: Exploring past, present and future perspectives, Reaper Review,19(4), 192-195. doi:10.1080/02783199709553827.

Duch, B. J., Groh, S. E. & Alen, D.E. (2001). The power of problem-based learning, a practical "how to" for teaching undergraduate courses in any discipline. Sterling, VA: Stylus.

Duman Ç. Z. & Akbaş, H. (2010). Nursing students' attitudes towards problem-based learning. DEUHYO ED, 3(3), 146-152. Retrieved from http://www.deu.edu.tr/UploadedFiles/Birimler/18278/146-152_pdf.pdf.

Durlak, J.A. (1995). Reading and understanding multivariate statistics. Washington, DC: American Psychological.

Edens, K. M. (2000). Preparing problem solvers for the 21st century through problem-based learning. College Teaching, 48(2), 55-60. doi:10.1080/87567550009595813.

Ergene, T. (1999). Effectiveness of test anxiety reduction programs: A meta-analysis review. (Unpublished Doctoral Thesis), Ohio University, USA.

Fidan, N. (1996). Okulda öğrenme ve öğretme. [Teaching and learning in schools]. Ankara: Alkım.

Field, A. P. (2001). Meta-analysis of correlation coefficients: a Monte Carlo comparison of fixed-and random-effects methods. Psychological methods, 6(2), 161-180. Retrieved from http://dx.doi.org/10.1037/1082-989X.6.2.161.

Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. Educational Researcher, 5(10) 3–8. Retrieved from http://www.jstor.org/stable/1174772.

Glass, G. V., McGaw, B. & Smith, M. L. (1981). Meta-analysis in social research. Beverly Hills, CA: Sage.

+Göğüş, R. (2013). Problem based learning teaching science and its effect on students academic achievement and attitudes. (Unpublished Master Thesis), Kirikkale University, Turkey.

Gömleksiz, M. N. (2003). Validity and reliability of an attitude scale on affective domain in English course. Firat University Journal of Social Science, (13)1, 215-226. Retrieved from dergipark.ulakbim.gov.tr.

+Gülseçen, S. & Kubat, A. (2006). Teaching ICT to teacher candidates using PBL: A qualitative and quantitative evaluation. Educational Technology ve Society, 9(2), 96-106. Retrieved from http://www.jstor.org/stable/jeductechsoci.9.2.96.

+Güneş, C. (2006). Studying the problem solving based learning method's effect on academic achievement and attitude towards the lesson in endocrine systems unit. (Unpublished Master Thesis), Gazi University, Turkey.

+Günhan, B. & Başer, N. (2008). Probleme dayalı öğrenme yönteminin öğrencilerin matematiğe yönelik tutumlarına ve başarılarına etkisi. Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 8 (1), 119-134.

Hastings, D. (2003). Case study: Problem based learning and the active classroom. Retrieved from http://www.tag.ubc.ca/facdev/services/newsletter/97/active.html.

Hedges, L. V. & Olkin, J. (1985). Statistical methods for meta-analysis. Orlando, Florida: Academic.

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

House, K. (2000). Mathematical problem solving in a grade 2 classroom. A Report of An Internship, 52-57. 11. Memorial University of Newfoundland. Retrieved from http://www.researchgate.net/publication/35736015.

+Hwang, S. Y. & Kim, M. J. (2006). A comparison of problem based learning and lecture based learning in an adult health nursing course. Nurse Education Today, 26, 315-321. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16364510.

Ilgaz, G. (2006). The attitudes of seventh grade towards the science course and learning strategy use. (Unpublished Master Thesis), Trakya University, Turkey.

+İnce Aka, E. (2012). The effect of problem-based learning method used for teaching acids and bases on different variables and students views on the method. (Unpublished Doctoral Thesis), Gazi University, Turkey.

+İşeri Gökmen, S. (2008). Effects of problem based learning on students' environmental attitude through local vs. non-local environmental problems. (Unpublished Master Thesis), Middle East Technical University, Turkey.

Johnstone, K. M. & Biggs, S. F. (1998). Problem-based learning: introduction, analysis, and accounting curricula implications. Journal of Accounting Education. 16(3), 407-427. doi:10.1016/S0748-5751(98)00026-8.

Kaptan, F. & Korkmaz, H. (2001). Problem based learning approach in science education. Hacettepe University Journal of Education, 20, 185-192. Retrieved from ulakbim.gov.tr.

+Karaöz, M. P. (2008). The effect of teaching the unit of ?power and motion? in primary school science course using the problem based learning approach on students science process skills, success and attitude. (Unpublished Master Thesis), Muğla University, Turkey.

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

+Kazemi, F. & Ghoraishi, M. (2012). Comparison of problem-based learning approach and traditional teaching on attitude, misconceptions and mathematics performance of University Students . Procedia Social and Behavioral Sciences, 46, 3852 - 3856. doi:10.1016/j.sbspro.2012.06.159.

Kenn, M. (1996). Problem based learning, issues of teaching and learning. Retrieved from http://csd.uwa.edu.au/newsletter.

Kocakaya, S. (2011). An educational dilemma: Are educational experiments working? Educational Research and Reviews, 6(1), 110-123. Retrieved from http://www.academicjournals.org/journal/ERR/article-abstract/8AF28104437.

+Koçak, M. & Ünlü, M. (2013). The effects of problem based learning on student's performance and motivation in geographic teaching. Marmara Geographic Journal, 1-17. Retrieved from http://dergipark.ulakbim.gov.tr/marucog/article/view/-1012000793/0.

+Koçakoğlu, M. (2008). The effect of problem based learning and motivational styles on students' academic success and attitudes towards biology course. (Unpublished Doctoral Thesis), Gazi University, Turkey.

+Kuşdemir, M., Ay, Y. & Tüysüz, C. (2013). An analysis of the effect of problem based learning model on the 10th grade students' achievement, attitude and motivation in the unit of "mixtures". Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, (7)2, 195-224. Retrieved from http://dergipark.ulakbim.gov.tr/balikesirnef/article/viewFile/5000084874/5000078956

Leary, H. M., (2012). Self-directed learning in problem-based learning versus traditional lecture-based learning: A meta-analysis. All Graduate Theses and Dissertations. Retrieved from http://digitalcommons.usu.edu/etd/1173.

Lewis, K. E. & Tamblyn, R. M. (1987). The problem-based learning approach in baccalaureate nursing education: How effective is it? Nursing Paper, 19(2), 17-26.

+Marum, T. (2009). PBL vs. DI: Which increases student achievement and attitude? (Unpublished Master Thesis), Western Governors University, USA.

Mierson, S. & Parikh, A. A. (2000). Stories from the field: Problem-based learning from a teacher's and a student's perspective. Change: The Magazine of Higher Learning, 32(1), 20-27. doi:10.1080/00091380009602705.

+Moralar, A. (2012). The effect of problem-based learning approach on academic success, attitude and motivation in science education. (Unpublished Master Thesis), Trakya University, Turkey.

Oskay-Özyalçın, Ö., Erdem, E. & Yılmaz, A. (2009). A study about the effects of chemistry laboratory applications on students' attitudes towards chemistry and achievement. Electronic Journal of Social Sciences, 8(27), 222-321. Retrieved from dergipark.ulakbim.gov.tr/esosder/article.

+Özdil, G. (2011). Effects of problem based learning approach on students? success in teaching the concepts of area and perimeter in seventh grade in primary schools. (Unpublished Master Thesis), Kastamonu University, Turkey.

+Özgen, K. (2007). The effects of problem based learning approach on learning products in mathematics lesson. (Unpublished Master Thesis), Dicle University, Turkey.

Özmen, F. (1999). Importance affective domain in realization of effective education - Love based training. Firat University Journal of Social Science, 1(9), 193-198. Retrieved from http://web.firat.edu.tr/sosyalbil/dergi/arsiv/cilt9/sayi1/193-198.pdf.

+Özsarı, T. (2009). The effect of cooperative learning method to the fourth grade students' achievement on mathematic learning: Problem based learning (PBL) and student teams achievement division method (STAD). (Unpublished Master Thesis), Ege University, Turkey.

+Penjvini, S. & Shahsawari, S. (2013). Comparing problem based learning with lecture based learning on medicine giving skill to newborn in nursing students. Journal of Nursing Education and Practice, 9(3), 53-59. doi: 10.5430/jnep.v3n9p53.

Phan, H. P. (2008). Unifying different theories of learning: Theoretical framework and empirical evidence. Educational Psychology, 28(3), 325-340. doi:10.1080/01443410701591392.

Pigott, T. D. (2012). Advances in meta-analysis. Springer: USA.

Radin, D. I. & Ferrari, D. C. (1991). Effects of consciousness on the fall of dice: A meta-analysis. Journal of Scientific Exploration, 5(1), 61-83. Retrieved from http://deanradin.com/evidence/Radin1991DiceMA.pdf.

+Rajab, A. M. (2007). The effects of problem-based learning on the self-efficacy and attitudes of beginning biology majors. (Unpublished Doctoral Thesis), University of California, USA.

+Reynolds, J. M. & Hancock, D. R. (2010). Problem-based learning in a higher education environmental biotechnology course, Innovations in Education and Teaching International, 47(2), 175-186. doi: 10.1080/14703291003718919.

Rudy, A. C. (2001). A Meta-analysis of the treatment of anorexia nervosa. (Unpublished Doctoral Thesis), Ithaca College, USA.

Saban, A. (2004). Öğrenme-öğretme süreci. Yeni teori ve yaklaşımlar. [Teaching-learning process. New theories and approaches]. Ankara: Gazi.

Sağlam, M. & Yüksel, İ. (2007). Meta-analysis and meta-evaluation methods in program evaluation. Dumlupinar University Journal of Social Science, 18, 175-188. Retrieved from http://birimler.dpu.edu.tr/app/views/panel/ckfinder/userfiles/17/files/DERG_/-18/175-188.pdf.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-Based Learning, 1(1), 3. doi: 10.7771/1541-5015.10

Schwarts, P., Mennin, S. & Webb, G. (Eds.) (2001). Problem-based learning: Case studies, experience and practice. London: Kogan Page.

+Selçuk-Sezgin, G. (2010). The effects of problem-based learning on pre-service teachers' achievement, approaches and attitudes towards learning physics. International Journal of the Physical Sciences, 5(6), 711-723. Retrieved from http://www.academicjournals.org/IJPS.

+Serin, G. (2009). The effect of problem based learning instruction on 7th grade students' science achievement, attitude toward science and scientific process skills. (Unpublished Doctoral Thesis), Middle East Technical University, Turkey.

+Sevening, D. & Baron, M. (2003). A comparison of traditional teaching methods and problem-based learning in an addiction studies class. Journal of Teaching in the Addictions, 1(2), 27-42. doi: 10.1300/J188v01n02_04.

Sifoğlu, N. (2007). The effects of constructivism and problem-based learning on students' success in the teaching the topic heritage' at the 8th grade. (Unpublished Master Thesis), Gazi University, Turkey.

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. doi: 10.7771/1541-5015.1046.

+Şahin, M. & Yörek, N. (2009). A comparison of problem-based learning and traditional lecture students' expectations and course grades in an introductory physics classroom. Scientific Research and Essay, 4(8), 753-762. Retrieved from http://www.academicjournals.org/SRE.

+Şalgam, E. (2009). The effect of problem based learning method on students' academic achievement and their attitude for physics lesson. (Unpublished Master Thesis), Dokuz Eylul University, Turkey.

Şendağ, S. & Odabaşı, F. H. (2009). Effects of an online problem based learning course on content knowledge acquisition and critical thinking skills. Computers and Education, 53(1), 132-141. doi:10.1016/j.compedu.2009.01.008.

+Şenocak, E., Taşkesenligil, Y. & Sözbilir, M. (2007). A study on teaching gases to prospective primary science teachers thorugh problem-based learning. Research in Science Education, 37, 279-290. Retrieved from http://www.academia.edu.

+Taşoğlu, A. K. (2009). The effect of problem based learning on students? achievements, scientific process skills and attitudes towards problem solving in physics education. (Unpublished Master Thesis), Dokuz Eylul University, Turkey).

+Tavukcu, K. (2006). The effects on the learning outcomes of problem based learning in science instruction. (Unpublished Master Thesis), Zonguldak Karaelmas University, Turkey.

Tolan, B. (1985). Toplum bilimlerine giriş: Sosyoloji ve sosyal psikoloji. [Introduction to the social sciences: Sociology and social psychology]. Ankara: Savaş.

Topçu, P. (2009). The effect of gender on computer attitude: A meta-analysis study. (Unpublished Master Thesis), Marmara University, Turkey.

+Tozo, A. T. (2011). The evaluation of the affect on student success and attitude of the subject which is Turkey's geopolitical position and regional problems via problem based learning technique. (Unpublished Master Thesis), Gazi University, Turkey.

Tseng, K. H., Chiang, F. K. & Hsu, W. H. (2008). Interactive processes and learning attitudes in a web-based problem-based learning (PBL) platform. Computers in Human Behavior, 24(3), 940-955. doi:10.1016/j.chb.2007.02.023.

+Tüysüz, C., Tatar, E. & Kuşdemir, M. (2010). Effect of the problem based learning on students' achievement and attitude in chemistry. Mustafa Kemal University Journal of Social Sciences Institute, 7(13), 48–55. Retrieved from http://sbed.mku.edu.tr/article/view/1038000590/0.

Uden, L. (2006). Technology and problem-based learning. C. Beaumont (Ed.). USA: IGI Global.

+Uslu, G. (2006). The Effect of problem based learning to attitudes, success and level of performance of the students in secondary school mathematics lessons. (Unpublished Master Thesis), Balikesir University, Turkey.

+Uygun, N. & Tertemiz, N. (2014). Effects of problem-based learning on student attitudes, achievement and retention of learning in math course. Education and Science, 39(174), 75-90. doi: 10.15390/EB.2014.1975.

Üstün, U. (2012). To what extent is problem based learning effective as compared to traditional teaching in science education? A meta-analysis study. (Unpublished Doctoral Thesis), Middle East Technical University, Turkey.

Üstün, U. & Eryılmaz, A. (2014). A research method to do effective research synthesis : Meta-analysis. Education and Science, 174(39), 1-32. doi: 10.15390/EB.2014.3379.

+Visser, Y. (2002). Effects of problem-based and lecture-based instructional strategies on problem solving performance and learner attitudes in a high school genetics class. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Walker, A. & Leary, H. (2009). A problem based learning meta analysis: Differences across problem types, implementation types, disciplines, and assessment levels.

Interdisciplinary Journal of Problem-based Learning, 3(1), 6-28. Retrieved from http://dx.doi.org/10.7771/1541-5015.1061.

Walton, H. J. & Matthews, M. B. (1989). Essentials of problem-based learning. Medical Education, 23, 542-558. doi: 10.1111/j.1365-2923.1989.tb01581.x.

Wilson, S. J., Lipsey, M. W. & Derzon, J. H. (2003). The effects of school-based intervention programs on aggressive behavior: a meta-analysis. Journal of Consulting and Clinical Psychology, 71(1), 136-151. doi: 10.1037/0022-006X.71.1.136.

Wolf, F. M. (1986). Meta-analysis: Quantitative methods for research synthesis. USA: Sage.

Woods, D.R. (1996). Problem based learning, helping your student gain the most from PBL. USA: Sage.

Yadav, A., Subedi, D., Lundeberg, M. A. & Bunting, C. F. (2011). Problem-based Learning: Influence on Students' Learning in an Electrical Engineering Course. Journal of Engineering Education, 100 (2), 253-280. doi: 10.1002/j.2168-9830.2011.tb00013.x

+Yurd, M. (2007). The effect of know-want-sample-learn strategy, which is developed by using problem based learning and know-want-learn strategy, towards the 5th grade students' attitudes in science and technology lesson and towards to remove their misconceptions. (Unpublished Master Thesis), Mustafa Kemal University, Turkey.

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