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A META-ANALYSIS STUDY COMPARING PROBLEM BASED LEARNING WITH TRADITIONAL INSTRUCTION

PROBLEME DAYALI ÖĞRENME YAKLAŞIMI İLE GELENEKSEL ÖĞRETİMİN KARŞILAŞTIRILMASI: BİR META-ANALİZ ÇALIŞMASI

Veli BATDI¹

Abstract

In this study, the efficiency of Problem-Based Learning (PBL) was compared with traditional methods. The effect size (ES) of PBL on academic achievement was calculated by using a meta-analytic method defined as drawing a general conclusion by analysing the data from a range of independent studies of similar subjects. Thus, 26 experimental studies were selected, which comply with the inclusion criteria determined with the help of research carried out between 2006 and 2013. The effect size of PBL on academic achievement was calculated as 1.302. According to Thalheimer and Cook's (2002) detailed level calculation, this value has a *very large* effect. The results of meta-analysis demonstrate that compared to traditional instruction methods, PBL has a positive effect on academic achievement.

Key Words: Problem-based learning, academic achievement, traditional method, meta-analysis, effect size.

Öz

Bu araştırmada probleme dayalı öğrenme (PDÖ) yaklaşımının etkililiğini geleneksel yöntem ile karşılaştıran çalışmaların meta-analizi yapılmıştır. Probleme dayalı öğrenmenin akademik başarı üzerindeki etki büyüklüğü benzer konularda birbirinden bağımsız ve çok sayıda yapılmış çalışmaların verilerini analiz ederek genel bir yargıya varma yöntemi olarak tanımlanan meta-analitik yöntem ile hesaplanmıştır. Bu amaçla 2006-2013 yılları arasında ilgili konuya ilişkin yapılan araştırmalardan belirlenen dâhil edilme kriterlerine uygun 26 adet deneysel çalışma meta-analiz için seçilmiştir. Araştırma sonucunda PDÖ'nün akademik başarıya olan etki büyüklüğü 1.302 olarak hesaplanmıştır. Bu değerin Thalheimer ve Cook (2002)'un ayrıntılı düzey sınıflamasına göre *çok geniş* etkiye sahip olduğu anlaşılmıştır. Ayrıca meta-analiz sonuçları PDÖ kullanımının geleneksel öğretim yöntemine göre akademik başarı açısından olumlu etki oluşturduğunu göstermiştir.

Anahtar Kelimeler: Probleme dayalı öğrenme, akademik başarı, geleneksel öğretim, meta-analiz, etki büyüklüğü.

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1. INTRODUCTION

Problem Based Learning (PBL) is based on a progressive approach which according to the view of John Dewey, is about introducing students to real life problems and giving them the opportunity to solve those problems (Dewey, 1996: as cited in Gökmen, 2008; Dolmans, De Grave, Wolfhagen, Vleuten, 2005). This learning style was introduced in medical education as an alternative to traditional instruction, because graduates were found to have knowledge but lacked the required problem solving skills to utilise this knowledge. We use it today in many fields including social sciences (Gallagher, Stepien, Sher, & Workman, 1995: as cited in Ward & Lee, 2002; Fatokun&Fatokun, 2013; Colliver, 2000; Savery& Duffy, 1995). PBL, which attaches primary importance to a student-centred quality (Akınoğlu&ÖzkardeşTandoğan, 2007) is now widely used in many parts of the world (HmeloSilver, 2004), and is a pedagogical approach based on the development of students' self-management skills. It enables them to understand theory and practice by getting to the heart of problems, and contributes to advanced cognitive skills such as creative thinking, problem solving, and communication (Major & Palmer, 2001). Learners who learn through PBL define their learning through triggers within the problems (Fatokun&Fatokun, 2013). With the help of these processes, they experience independent and self-oriented learning before discussing and correcting information from group discussions. It is right to call PBL an approach that uses appropriate problems to increase knowledge and understanding instead of characterising it as simply a method of problem solving (Awang&Ramly, 2008; Könings, Wiers, Wiel,&Schmidt, 2005). To put it another way, PBL produces solutions to problems by learners' working together to define and analyse existing problems (Peterson, 1997). Research shows that to some extent students' critical skills develop in group discussions aimed at solving problems in the PBL process (Tiwari, Chan, Sullivan, Dixon, & Tang, 1999; Parton & Bailey, 2008; Yoon, Woo, Treagust,&Chandrasegaran, 2014; Demirel&ArslanTuran, 2010).

PBL is successfully implemented in educational settings, as it develops the skills, meaningful learning, and advanced thinking of learners and encourages a satisfying learning performance (Tsai & Chiang, 2013). We should note the six basic features of PBL put forward by Barrows (1996). First, learning should be student-centred. Second, we should implement it in small groups under the guidance of a teacher. Third, the teacher should be in a guiding or directing role. Fourth, real problems should be included in the learning process without any preliminary preparation or study. Fifth, we should use problem-solving skills on the problems we encounter while accessing the required information. Finally, we should

obtain new information through self-oriented learning (as cited in Dochy, Segers, Bossche, & Gijbels, 2003). In PBL, learners use individual effort to access the required information to research and solve a problem. As the problems encountered using this approach are real life ones, we provide the learner with information they can make use of in life, so we expect an increase in enthusiasm, motivation and interest throughout the learning process.

When we study the literature on PBL, the results suggest that it is effective in facilitating learning (Dochy et al., 2003; Teyyeb, 2013; Selçuk, 2010), providing real life competencies and increasing motivation (Hallinger & Lu, 2011; Major & Palmer, 2001; Norman & Schmidt, 2000; Smith et al., 2005; Colliver, 2000; Newman, 2001; Nandi, Chan, et al., 2000; Achuonye, 2010). The PBL approach is the subject of our study. It emphasises learning using real life problems, which the student unravels, discovers their causes and finds solutions using existing knowledge and competence.

2. METHOD

We undertake this study in order to determine the effect of PBL on the academic achievement and permanence scores of students using a meta-analytic effect size analysis. We make various definitions of meta-analysis such as the method of synthesising the findings of independent studies and comparing their results (Akgöz, Ercan, & Kan, 2004). We use an analytic procedure that involves making parametric estimates on the society by bringing together the results of studies carried out on the same subject in different places and at different times (Şahin, 1999), or by calculating the effect size value and having a summary result that combines the findings of previous studies (Kınay, 2012). Meta-analysis has some common features such as generating the problem in terms of collecting, encoding, analysing and interpreting data (Cooper & Hedges, 1994a: as cited in Walker & Leary, 2009). In this study, we seek to answer the question “What is the effect of PBL on the academic achievement of students?”

2.1. Collecting the Data

In this study masters’ and PhD theses concerning the PBL were made use of. The data collection was made by searching the “National Thesis Centre of Turkish Higher Education Council” and by using the “Google scholar” search engine using the following key words; “*problem-based learning environments, problem-based learning and academic achievement, problem-based learning, the effect of problem based learning*” in both Turkish and English.

93 theses; 87 Masters' and six PhDs were found as a result. These studies comply with the inclusion criteria so they were included in the study. We use a pre-test-post-test control group, study the effect of the PBL approach on the academic achievement of students, include the sample size (n), mean (X) and standard deviation (sd) values belonging to experimental-control groups and we test and implement it in Turkey between the years 2006 and 2013. We eliminated all studies that lacked the prerequisites required for meta-analysis study, and selected 26 theses.

2.2. The Method of Encoding

We encode the identifying information and quantitative data in a summary table. We present both general and specific information to identify each study and to explain the detail. We present the data we obtained in this study as "study identity", as the name of the author, year of publication, type of publication, instructional level and course type, subject, sample size and the duration of implementation (weeks) (Appendix 1). We fix the descriptive statistics using the sample size, the mean, and standard deviation data to be used in the meta-analysis calculation as "study data".

2.3. Dependent Variables

We determine the effect size of the PBL approach included in meta-analysis, by using a calculation based on academic achievement scores as the dependent variable. We define effect size in various forms such as the standardised value for various means of measurement concerning each of the studies (Bernard et al., 2004) or an index value used to determine how effective is the case to be studied (Küçükönder, 2007). The fact that the scales and measurement results differ from each other necessitates obtaining a standard value. Thus, it is essential to interpret the findings correctly using standard values following the calculation of effect sizes.

2.4. Study Characteristics

We define the independent variables belonging to meta-analysis as study characteristics. These characteristics are the level of education of the students, the courses on which we implement the study, type of publication, year of study, volume, standard deviation and mean values of the samplings.

2.5. Data Analysis

We analyse the data in this study using the meta-analysis method. The main aim is to combine the effect sizes of experimental studies, in other words, to calculate the differences between the mean scores of experimental and control groups (Hunter, & Schmidt, 1990: as cited in Acar, 2011). The effect size in experimental studies indicates the effect strength of the result reached when the factor exists compared to the result reached when the factor does not exist (Şahin, 1999). In this study, we calculate the effect size value using the “Cohen d ” method. We obtain the effect size “ d ” by dividing the difference between the mean scores of the two groups into total standard deviation (Cohen, 1992). In this study, the effect size values are given according to Thalheimer and Cook’s (2002) detailed level classification ($-0.15 < \text{Cohen’s } d < 0.15$ *negligible*; $0.15 < \text{Cohen’s } d < 0.40$ *small*; $0.40 < \text{Cohen’s } d < 0.75$ *medium*; $0.75 < \text{Cohen’s } d < 1.10$ *large*; $1.10 < \text{Cohen’s } d < 1.45$ *very large* and $1.45 < \text{Cohen’s } d$ *huge*).

We make inferences to analyse the effect coefficients calculated for each study based on fixed effects and random effects models (FEM/REM). We use Comprehensive Meta-Analysis (CMA), MetaWin statistics and Microsoft Excel 2010 to find the effect sizes and variances belonging to each of the studies and to compare the groups.

3. FINDINGS

We analyse 26 theses using meta-analytic analysis regarding a PBL approach in learning environments. In Table 1, we provide the statistics showing the level of education, subject areas, implementation period, type of publication, course type in which the study was implemented, year when the study was carried out, frequencies and percentages of these studies. When we examine the level of education in Table 1 we can see that most of the studies were carried out in secondary schools (50%), 26.92% at undergraduate level, 15.38% at high school with only a few studies in primary schools (7.69%). Most of the studies were carried out in the field of science (61.54%) with 16 studies and five studies in the field of each mathematics and the social sciences (19.23%). When we consider the implementation periods, we can see that most of the 26 studies examining academic achievement were carried out in five to six week periods (26.92%).

When we consider the course type in Table 1, we can see that most of the studies were carried out in Mathematics (23.08%) followed by Science and Science and Technology with

five studies each (19.23%). There are three studies in Geography and Physics (11.54%), two in Chemistry (7.69%), one in English and Life Sciences (3.85%).

Table 1. Frequency and Percentage Values of the Studies Including Data Regarding the Academic Achievement Scores of Using a PBL Approach in Learning Environments

Variable	(f)	(%)	Variable	(f)	(%)			
Level of Education			Type of Publication					
Primary	2	7.69	Master’s Thesis	22	84.61			
Secondary	13	50	PhD Thesis	4	15.38			
High	4	15.38	Course Type, Year, Frequency and Percentage Values					
Undergraduate	7	26.92	Course Type	(f)	(%)	Year	(f)	(%)
Subject Areas			Science	5	19.23	2006	1	3.85
Science	16	61.54	Science and Tech.	5	19.23	2007	3	11.54
Mathematics	5	19.23	Mathematics	6	23.08	2008	3	11.54
Social Sciences	5	19.23	Geography	3	11.54	2009	4	15.38
Implementation Period (Weeks)			Physics	3	11.54	2010	7	26.92
2-4	6	23.08	Chemistry	2	7.69	2011	6	23.08
5-6	7	26.92	English	1	3.85	2012	2	7.69
7-8	5	19.23	Life Sciences	1	3.85			
9-18	5	19.23						
Not specified	3	11.54						

In Table 2, we show the homogenous distribution value, the mean effect size and confidence intervals in the effect models regarding the academic achievement scores of the studies included in meta-analysis. We can say that according to the fixed effects model, there is a positive effect on academic achievement of using materials in learning environments with a value of 0.939 effect size. Because of the homogeneity test, we found the Q_B statistical value to be 305.381. We accept the critical value as 37.652 from the χ^2 table at a 95% confidence interval with 25 degrees of freedom. As we found the Q_B statistical value (305.381) higher than the critical value (37.652), we can claim that the distribution of effect sizes is heterogeneous.

Table 2. Homogeneous Distribution Value, Mean Effect Size, and Confidence Intervals in the Effect Models Regarding the Academic Achievement Scores of the Studies

Model Type	N	Z	Q_B	ES	95% Confidence Interval	
					Lower Limit	Upper Limit
FEM	26	17.361	305.381	0.939	0.833	1.045
REM	26	6.745	46.537	1.302	0.924	1.680

Since the distribution in this study is heterogeneous, we try to prevent possible mistakes resulting from a heterogeneous sampling by making analyses complying with the random effects model. Therefore, we compare the efficiency of instruction using PBL with the instruction performed without using PBL according to the random effects model. We analyse the data in the 26 theses included in the meta-analysis using the random effects model with 0.193 standard error and at a 95% confidence interval, the upper limit being 1.680, the lower limit being 0.924 and the effect size 1.302. We can say that the effect size value is in the very large effect interval according to the classification of Thalheimer and Cook (2002), and thus the use of PBL in learning environments has a positive effect on academic achievement.

3.1. The Efficiency of Using the Problem Based Learning Approach in Accordance with the Implementation Periods of Studies

We classify the studies as 2-4 weeks, 5-6 weeks, 7-8 weeks, and 9-18 weeks in order to determine whether the effect size of using PBL differs according to the implementation periods of the studies. Where the study implementation period is not given or given as course hours we classify this as the fifth group with the note “not specified”. We show the results of analyses according to the groups in Table 3.

Table 3.Effect Sizes According to the Study Implementation Periods

Implementation Period	N	ES	95% Confidence Interval for Effect Size	
			Lower Limit	Upper Limit
2-4	6	1.056	0.241	1.871
5-6	7	0.775	0.019	1.531
7-8	5	1.485	0.591	2.378
9-18	5	2.491	1.565	3.417
Not specified	3	0.916	-0.240	2.073
Total	26	1.308	0.913	1.702

$$Q_B=9.139 \quad Z=6.494 \quad df=4 \quad p=0.058$$

According to the results of the analyses in Table 3, we observe the highest effect size in the 9-18 weeks implementation period with the value 2.491 and the lowest in the 5-6 weeks implementation period with the value 0.775. As a result of the homogeneity test, we calculate the Q_B statistical value as 9.139. We accept the critical value as roughly 4.488 from the χ^2 table at 95% confidence interval with the degree of freedom four. As the calculated homogeneity value (9.409) is higher than the critical value (4.488), we can say it has a heterogeneous distribution. Keeping this in mind, we can claim that there are no significant differences between the groups formed when the studies included in meta-analysis are

grouped according to their implementation periods and we consider their effect sizes ($Q_B = 9.139$; $p=0.058$). In the light of our findings, academic achievement in the courses taught using PBL does not differ according to the implementation periods of PBL. We can claim that PBL has a similarly large effect in all the groups.

3.2. The Efficiency of Using Problem Based Learning According to Subject Areas

We classify the courses into three groups; Science (Physics, Chemistry, Science, Science and Technology); Mathematics (Mathematics) and Social (Geography, English, Life Sciences, Turkish) to determine the effect of the courses in which the studies were carried out on total effect size. We show the results of analyses according to these groups in Table 4.

Table 4. The Effect Sizes of the Courses According To Subject Areas

Subject Areas	N	ES	95% Confidence Interval for Effect Size	
			Lower Limit	Upper Limit
Science	15	1.323	0.819	1.826
Mathematics	6	0.785	-0.003	1.574
Social	5	1.888	1.009	2.768
Total	26	1.303	0.921	1.685

$$Q_B=3.361 \quad Z=6.683 \quad df=2 \quad p=0.186$$

According to the results in Table 4, we observe the highest effect size in courses in the Social group with the value 1.888. We observe the lowest in courses in the Mathematics group with the value 0.785. As a result of the homogeneity test, we calculate the Q_B statistical value as 3.361. We accept the critical value as roughly 5.991 from the χ^2 table at 95% confidence interval with the degree of freedom 2. As the Q_B statistical value (3.361) we calculate in this study is lower than the critical value (5.991), we accept the homogeneity hypothesis of the distribution of effect sizes in the Fixed Effects Model. We can claim the distribution to be homogeneous and can say that there are no significant differences in terms of effect sizes ($Q_B=3.361$; $p=0.186$) among the subject area groups. Therefore, there is no significant difference between the subject area groups on academic achievement when using PBL.

3.3. Results of Analyses Concerning Permanence Scores of Studies Included in Meta-Analysis

When we consider the sum of the seven Masters theses, where the permanence scores of students in learning environments using PBL are compared with those in traditional learning environments, the experimental group consists of 256 students and the control group

257. We analyse the general characteristics of the studies and effect sizes using the sampling size, standard deviations, and mean scores of the studies. In Table 5, we provide the homogeneous distribution value, mean effect size and confidence intervals according to the effect model concerning the permanence scores of the theses included in meta-analysis as a result of using the related approach in the learning environment.

We can see the results of the analyses carried out in accordance with the fixed effect model in Table 5. We calculate that the permanence scores of academic achievement are better for PBL, than those obtained for traditional instruction with the standard error 0.092; the upper limit of 95% confidence interval being 0.612 and the lower level 0.252 having an effect size of 0.432. We accept this effect size as a medium effect according to the classification made by Thalheimer and Cook (2002). As a result of z test computations performed for statistical significance, we find $z=4.707$. Thus, we can say that the analysis was significant with the $p=0.000$ value in hand.

Table 5. Homogeneous Distribution Value, Mean Effect Size, and Confidence Intervals in the Effect Models Regarding the Permanence Scores of the Studies Included in Meta-Analysis

Model Type	n	Z	p	Q _B	df	ES	95% Confidence Interval	
							Lower Limit	Upper Limit
FEM	7	4.707	0.000	73.188	6	0.432	0.252	0.612
REM	7	1.736	0.083	7.917		0.592	-0.076	1.260

As a result of the homogeneity test, we calculate the Q_B statistical value as 73.188. From the χ^2 table at 95% confidence interval, we find the critical value to be 12.592 with 6 degrees of freedom. We observe that the Q_B statistical value (73.188) exceeds the critical value of χ^2 distribution ($\chi^2_{(0.95)}=12.592$) having 6 degrees of freedom. In the light of this data, we determine the effect size distributions of the studies to be heterogeneous according to the fixed effect model. Therefore, we also compare the efficiency of permanence scores of PBL according to the random effects model, as it is possible that mistakes were destroyed in the heterogeneous samples due to data analysis using the random effects model instead of the fixed effects model.

As a result of random effects model analysis, we discover that the permanence scores of academic achievement using PBL are better than those where traditional instruction methods are used, with a standard error of 0.341; the upper limit of 95% confidence interval being 1.260, lower limit -0.076 and mean effect size 0.592. As a result of z test calculations realised for statistical significance, we find that $z=1.736$ and $p=0.083$. We conclude that

according to the random effects model, there is no significant difference in the permanence scores of students using PBL in the learning environment.

4. DISCUSSION AND CONCLUSIONS

According to data obtained from 26 research studies in this meta-analysis study including Masters and PhD theses in Turkey, and from examining the use of PBL in learning environments, there is a positive effect on academic achievement when taught using PBL. Thalheimer and Cook (2002), classify this effect as *very large*. This demonstrates that using PBL the efficiency level with respect to academic achievement is high. We obtain this result from research carried out nationally, which is supported by international literature and a number of different studies. We exclude Demirel and Turan, 2010; and Deveci, 2002 from the analysis but there are parallel results to those of the analysis by Akinoğlu and Özkardeş Tandoğan, 2007; Selçuk, 2010; Nafees, Farooq, Tahirkheli and Akhtar 2012. Dochy et al., (2003) examined many studies carried out at an international level using meta-analysis and conclude that in the learning environments where PBL is used academic achievement is higher than found when using other approaches. Moreover Batdı's (2014) meta-analytic research about the effect of Jigsaw technique on academic achievement of students showed parallel results that the jigsaw technique has high efficiency level on academic achievement of students.

In this meta-analysis, we analyse whether or not the effect size differs according to implementation periods, subject areas and permanence scores. We split the studies into five different groups in terms of their implementation periods; 2-4, 5-6, 7-8, 9-18 weeks and *not specified*. When we examine the effect sizes of the groups, we observe that all the groups have positive values; we can see the highest effect size in 9-18 weeks of implementation with the value 2.491 and the lowest effect size in 5-6 weeks of implementation with the value 0.775. In terms of subject areas, the effect sizes in all three groups - science, mathematics, and social - are positive, the highest effect size being in courses grouped under *social* with the value 1.888 and the lowest effect size in courses grouped under *mathematics* with the value 0.785. The efficiency level of using PBL in all three levels of education falls into the category of "very large effect" according to the classification of Thalheimer and Cook (2002). On the other hand, we can say that there are no significant differences in terms of effect sizes according to the implementation periods, and the effect of using PBL in the courses mentioned in terms of academic achievement does not differ according to implementation periods. Hence, we observe that PBL has a very similar large effect in all groups. In previous

meta-analysis studies of different subjects in Turkey, we examine whether or not the effect size differs according to the implementation periods. Çapar's study (2011) determines that effect sizes do not differ according to implementation periods.

When we exclude the mean effect sizes belonging to the seven studies which include the permanence scores of students in the meta-analysis and calculate in accordance with the random effects model, we discover that permanence scores for PBL are better than those where traditional instruction methods are used with a standard error of 0.341; the upper limit of 95% confidence interval is 1.260 and the lower level -0.076, having a mean effect size of 0.592. We accept this effect size as "medium", according to the classification of Thalheimer and Cook (2002). When we examine the values of mean effect sizes of the studies included in meta-analysis, and include analysis results regarding the permanence scores, we calculate them at insignificant levels in two studies (Korucu, 2007; Akın, 2009), at small levels in one study (Sifoğlu, 2007), at medium levels in another study (Uslu, 2008), at large levels in two other studies (Çelik, 2010; Uygun, 2010) and at an excellent level in another study (Benli, 2010). When we consider the results of the analysis, we find that using PBL in learning environments positively affects the permanence scores of students. However, in a study examining the permanence scores of students using PBL, it was determined that there was no significant difference in terms of the results of permanence test (Korucu, 2007). The reason there was no significant difference in permanence about this disputable subject is that the permanence test was implemented just before the study, so there are doubts about the external validity of the study (Dinçer&Güçlü, 2013). However, according to the findings of studies in general, a constructivist learning approach is more successful than traditional instruction with regard to the permanence scores of students.

From our experiments and from examining the studies in terms of academic achievement and permanence, we recommend the encouragement of PBL in learning environments. We suggest that teachers use this approach carefully as it has a high effect on students' academic achievements. In this research, we study the efficiency level of PBL with respect to academic achievement and permanence. In future meta-analysis studies, we recommend the examination of the efficiency of this approach in terms of the attitudes of students. This study is limited in its findings, as it only includes Masters and PhD theses from Turkey. A more comprehensive study could be carried out, if data from abroad was included and if we examined different types of publications.

REFERENCES

(The references marked with an asterisk (*) are the ones used in meta-analysis study).

- Acar, S. (2011). *Bilgisayar destekli öğretimin öğrencinin Fizik Kimya biyoloji ve Mathematics alanlarındaki tutumlarına olan etkisinin meta analiz yöntemi ile incelenmesi* [Examining the effect of computer-based education on students' attitudes in the fields of Physics, Chemistry, Biology and Maths through meta-analysis method].(Unpublished master's thesis).YüzüncüYılUniversity, Van.
- Achuonye, K. A. (2010). A comparative study of problem-based and lecturebased learning in secondary school students' motivation to learn science. *International Journal of Science and Technology Education Research*, 1(6), 126-131.
- Akgöz, S., Ercan, İ.,& Kan, İ. (2004).Meta-analizi [Meta-analysis].*Journal of UludağUniversity Faculty of Medicine*, 30(2), 107-112.
- *Akın, G. (2010). *Andragojik ilkelere göre geliştirilmiş problem temelli mesleki İngilizce eğitimi programının etkililiği* [Efficiency of a problem-based esp training (vocational English) program enhanced by principles of andragogy].(Unpublished doctoral dissertation).Ankara University, Ankara.
- *Akın, P. (2009). *İlköğretim 5. sınıf Matematik dersi için probleme dayalı öğrenme yönteminin öğrenci başarısına etkisi*[The effects of problem-based learning on students' success in the teaching the topic fractions at the 5th grade].(Unpublished master's thesis).EgeUniversity, İzmir.
- Akinoğlu, O. &ÖzkardeşTandoğan, R. (2007).The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning.*Eurasia Journal of Mathematics, Science & Technology Education*, 3(1), 71-81.
- *Alagöz, B. (2009). *Sosyal bilgiler öğretmen adaylarında çevre bilincinin geliştirilmesinde probleme dayalı öğrenme yönteminin etkisi*[Effect of problem based learning method in promoting environmental consciousness in candidate social studies teachers]. (Unpublished doctoral dissertation).Gazi University, Ankara.
- *Altunçekiç, A. (2010). *Web destekli probleme dayalı öğrenme ortamlarının bilişsel ve duyuşsal öğrenme ürünlerine etkisi: gazi üniversitesi kastamonu eğitim fakültesi örneği* [The effect of web supported problem based learning medium upon cognitive and effective learning products: Gazi University Kastamonu education example].(Unpublished doctoral dissertation).Gazi University, Ankara.
- Awang, H. &Ramly, I. (2008). Creative thinking skill approach through problem-based learning: pedagogy and practice in the engineering classroom. *International Journal of Human and Social Sciences* 3(1), 18-23.
- *Ayvacı, A. (2011).*Probleme dayalı öğrenme yaklaşımının denklem kavramının öğretiminde etkisi* [The effect of problem-based learning approach on teaching the concept of equation].(Unpublished master's thesis).Kastamonu University,Kastamonu.
- Batdı, V. (2014).Jigsaw tekniğinin öğrencilerin akademik başarılarına etkisinin meta-analiz yöntemiyle incelenmesi.*EkevAkademiDergisi*. 58, 699-714.
- *Benli, E. (2010).*Probleme dayalı öğrenmenin Fen öğretmen adaylarının akademik başarılarına, bilgilerin kalıcılığına ve fene karşı tutumlarına etkilerinin araştırılması* [The research of the effects of problem based learning to the permanence of

- information, the academic success of scienceteacher candidates and their attitudes toward science].(Unpublished master's thesis).Gazi University, Ankara.
- Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L. et al. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature.*Review of Educational Research*, 74(3), 349-361.
- *Çelik, E. (2010). *Fen eğitiminde probleme dayalı öğrenme yaklaşımının öğrencilerin akademik başarısına, tutumuna, akademik risk alma düzeyine ve kalıcılığa etkisi* [The effect of problem based learning approach in science education on students' academic achievement, attitude, academic risk taking level and retention of knowledge]. (Unpublished master's thesis).Gazi University, Ankara.
- *Çetin, P. (2011).*İlköğretimde hayat bilgisi dersinde probleme dayalı öğrenme yöntemi uygulamalarının öğrencilerin öğrenme ürünlerine etkisi* [The Effect of Problem Based Learning Applications on Learning Outcomes of the Students in Primary Education Life Studies Course].(Unpublished master's thesis).DokuzEylül University, İzmir.
- Cohen, J. (1992). Statistical power analysis.*Current Directions in Psychological Science*,1(3), 98-101.
- Colliver, J. A. (2000). Effectiveness of Problem-based Learning Curricula:Research and Theory. *Academic Medicine*, 75(3), 259-266.
- Demirel, M.&ArslanTuran, B. (2010).The effects of problem based learning on achievement, attitude, metacognitive awareness and motivation. *Hacettepe University Journal of Education*, 38, 55-66.
- Deveci, H. (2002). *Sosyal bilgiler dersinde probleme dayalı öğrenmenin öğrencilerin derse ilişkin tutumlarına, akademik başarılarına ve hatırlama düzeylerine etkisi* [The effect of problem-based learning on students' attitudes, their level of academic achievement and recall in Social Studies lessons]. (Unpublished doctoral dissertation).Anadolu University,Eskişehir.
- Dinçer, S.,&Güçlü, M. (2013).Fen eğitiminde bilgisayar destekli simülasyon kullanımının etkililiği ve yeni yönelimler: Bir meta-analiz çalışması [Effectiveness of using computer-aided simulation in Science Education and new trends:A meta-analysis]. *International Journal of Human Sciences*, 10, 49-66.
- Dochy, F., Segers, M., Bossche, P. V.,&Gijbels, D. (2003). Effects of problem-based learning: a meta-analysis. *Learning and Instruction* 13, 533–568.
- Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I. H. A. P., &Vleuten, C. P. M. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education*, 39, 732–741.
- Fatokun, J. O. &Fatokun, K. V. F. (2013).A problem based learning (PBL) application for the teaching of Mathematics and Chemistry in higher schools and tertiary education: An integrative approach. *Educational Research and Reviews*, 8(11), 663-667.
- Hallinger, P. & Lu, J. (2011): Implementing problem-based learning in higher education in Asia: challenges, strategies and effect.*Journal of Higher Education Policy and Management*, 33(3), 267-285.
- Yoon, H., Woo, A. J., Treagust,D., &Chandrasegaran, A.L. (2014).The efficacy of problem-based learning in an analytical laboratory course for preservice chemistry teachers.*International Journal of Science Education*, 36(1), 79-102. doi:10.1080/09500693.2012.727041

- Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review*, 16(3), 235-266.
- *İnce Aka, E. (2012). *Asitler ve bazlar konusunun öğretiminde kullanılan probleme dayalı öğrenme yönteminin farklı değişkenler üzerine etkisi ve yönteme ilişkin öğrenci görüşleri* [The effect of problem-based learning method used for teaching acids and bases on different variables and students' views on the method]. (Unpublished doctoral dissertation), Gazi University, Ankara.
- İşeriGökmen, S. (2008). *Effects of problem based learning on students' environmental attitude through local vs. non local environmental problems*. (Unpublished master's thesis). Middle East Technical University, Ankara.
- *Kaçar, S. (2012). *Görsel sanatlarla bütünleştirilmiş probleme dayalı öğrenme yönteminin öğrencilerin fen akademik başarılarına, bilimsel yaratıcılıklarına ve sanat etkinlikleriyle fen öğrenme tutumlarına etkileri*. [The effects of problem based learning method integrated visual arts on students' academic achievements, scientific creavities and attitudes towards science teaching with art activities]. (Unpublished master's thesis). Dokuz Eylül University, İzmir.
- Kınay, E. (2012). *Üniversite giriş sınavı yordama geçerliği çalışmalarının meta analizi*. [Meta-analysis of predictive validity of university entrance exam]. (Unpublished master's thesis). Ankara University, Ankara.
- *Koçak, M. (2008). *Ortaöğretimde Coğrafya öğretiminde probleme dayalı öğrenme yaklaşımının öğrenci performansı ve motivasyonu üzerine etkisi* [The effect of problem based learning to attitudes, success and level of permanence of the students in secondary school geography lessons]. (Unpublished master's thesis). Marmara University, Istanbul.
- Könings, K. D., Wiers, R. W., Wiel, M. W. J., & Schmidt, H. G. (2005). Problem-based learning as a valuable educational method for physically disabled teenagers? The discrepancy between theory and practice. *Journal of Developmental and Physical Disabilities*, 17(2), 107-117. doi: 10.1007/s10882-005-3683-6.
- Küçükönder, H. (2007). *Meta analiz ve tarımsal uygulamalar* [Meta-analysis and agricultural applications]. (Unpublished master's thesis). Sütçü İmam University, Kahramanmaraş.
- *Kuşdemir, M. (2010). *Probleme dayalı öğrenmenin öğrencilerin başarı, tutum ve motivasyonlarına etkisinin incelenmesi* [An analysis of the effect of problem based learning model on the students succes, attitude and motivations]. (Unpublished master's thesis). Mustafa Kemal University, Hatay.
- Major, C. H., & Palmer, B. (2001). Assessing the effectiveness of problem based learning in higher education: Lessons from the literature. *Academic Quarterly*, 5(1).
- *Moralı, A. (2011). *The effect of problem-based learning on academic achievement, attitude and motivation in Science Education* [Fen eğitiminde problem dayalı öğrenme yaklaşımının akademik başarı, tutum ve motivasyona etkisi]. (Unpublished master's thesis), Trakya University, Edirne.
- Nafees, M., Farooq, G., Tahirkheli, S. A., & Akhtar, M. (2012). Effects of instructional strategies on academic achievement in a high school general science class. *International Journal of Business and Social Science*. 3(5), 161-166.

- Nandi, P. L., Chan, J. N. F., Chan, C. P. K., Chan, P., & Chan, L. P. K. (2000). Undergraduate medical education: comparison of problem-based learning and conventional teaching. *HKMJ*, 6(3), 301-306.
- *Nedime Korucu, E. (2007). *Problemedayalı öğretim ve işbirlikli öğrenme yöntemlerinin ilköğretim öğrencilerinin başarıları üzerine etkileri* [Comparing with problem and cooperative based learning method applied in primary schools on the success of the students]. (Unpublished master's thesis), Selçuk University, Konya.
- Newman, M. (2001). How effective is problem-based learning? *Education for Health*, 14(2), 333-334.
- Norman, G., & Schmidt, H. (2000). Effectiveness of problem-based learning curricula: Theory, practice, and paper darts. *Medical Education*, 34, 721-728.
- Özdemirli-Çapar, G. (2011). *İşbirlikli öğrenme yönteminin öğrencinin Matematik başarıları ve matematiğe ilişkin tutumu üzerindeki etkililiği: bir meta-analiz çalışması*. [The effectiveness of cooperative learning method on students' Maths achievement and attitudes towards Maths: a meta-analysis]. (Unpublished master's thesis), Çukurova University, Adana.
- *Özdil, G. (2011). *Probleme dayalı öğrenme yaklaşımının ilköğretim 7.sınıflarda çevre ve alan kavramı öğretiminde öğrenci başarısına etkisi* [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's thesis), Kastamonu University Kastamonu.
- *ÖzkardeşTandoğan, R. (2007). *Fen eğitiminde problem dayalı aktif öğrenmenin öğrencilerin başarılarına ve kavram öğrenmelerine etkisi* [The effects of problem based active learning on the student's academic achievement and learning concepts on science education]. (Unpublished master's thesis), Marmara University, İstanbul.
- *Özsarı T. (2009). *İlköğretim 4.sınıf öğrencileri üzerinde işbirlikli öğrenmenin Matematik başarıları üzerine etkisi: problem dayalı öğrenme (PDÖ) ve öğrenci takımları-başarı bölümleri (ÖTBB)* [The effect of cooperative learning method to the fourth grade student' achievement on mathematics learning: problem based learning (PBL) and student teams- achievement division methods (STAD)] (Unpublished master's thesis), Ege Üniversitesi, İzmir.
- *PakyürekKaraöz, M. (2008). *İlköğretim Fen ve Teknolojidersi "kuvvet ve hareket" ünitesinin problem dayalı öğrenme yaklaşımıyla öğretiminin öğrencilerin bilimsel süreç becerileri, başarıları ve tutumları üzerine etkisi*. [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's thesis), Muğla University, Muğla.
- Parton, G. & Bailey, R. (2008) Problem-based learning: a critical rationalist perspective. *London Review of Education*, 6(3), 281-292. doi:10.1080/14748460802528475
- Peterson, M. (1997). Skills to enhance problem-based learning. *Med Educ online* [serial online] 2,3. Retrieved from <http://www.utmb.edu/meo/>
- *Şahin, A. (2011). *Genel Fizik laboratuvar dersinde basit elektrik devreleri konusunun öğretilmesinde problem dayalı öğrenme (PDÖ) yaklaşımının öğrencilerin akademik başarılarına etkisinin incelenmesi* [To Analyse the Effect of Problem Based Learning (PBL) Approach on Academic Success of Students in Teaching Basic Electrical

- Circuits in General Physics Laboratory Course]. (Unpublished master's thesis), Atatürk University, Erzurum.
- Şahin, F. (1999). Meta analizin tıpta kullanımı ve bir uygulama.[Using meta-analysis in medicine and an application].(Unpublished doctoral dissertation), Osmangazi University, Eskişehir.
- *Şalgam, E. (2009). *Fizik eğitiminde problem dayalı öğrenme yönteminin öğrencilerin akademik başarılarına ve tutumlarına etkisi*[The Effect of Problem Based Learning Method on Students' Academic Achievement and Their Attitude on Physics Education].(Unpublished master's thesis), Dokuz Eylül University, İzmir.
- Savery, J. R. & Duffy, T. M. (1995).Problem based learning: an instructional model and its constructivist framework. *Educational Technology*, 35, 31-38.
- Selçuk, G. S. (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.
- *Sifoğlu, N. (2007). *İlköğretim 8.sınıf Science dersinde yapısalcı öğrenme ve problem dayalı öğrenme yaklaşımlarının öğrenci başarıları üzerine etkisi*. [The effects of constructivism and problem-based learning on students' success in the teaching the topic heritage" at the 8th grade].(Unpublished master's thesis), Gazi University, Ankara.
- Smith, K., Sheppard, S., Johnson, D., & Johnson, R. (2005). Pedagogies of engagement: Classroombased practices. *Journal of Engineering Education*, 94(1), 87-102.
- *Tavukçu, K. (2006). *Fen dersinde problem dayalı öğrenmenin öğrenme ürünlerine etkisi* [The effect of problem-based learning on learning product in Science Education]. (Unpublished master's thesis), Zonguldak Karaelmas University, Zonguldak.
- Teyyeb, R. (2013). Effectiveness of problem based learning as an instructional tool for acquisition of content knowledge and promotion of critical thinking among medical students. *Journal of the College of Physicians and Surgeons*, 23(1), 42-46.
- Thalheimer, W., & Cook, S. (2002).*How to calculate effect sizes from published research articles: A simplified methodology*. A part of book. Retrieved from http://education.gsu.edu/coshima/EPRS8530/Effect_Sizes_pdf4.pdf
- Tiwari, A., Chan, S., Sullivan, P.L., Dixon, A.S.,& Tang, C. (1999) Enhancing students' critical thinking through problem-based learning. In J. Marsh (Ed.)*Implementingproblem based learning project: proceedings of the first asia pacific conference on problem based learning* (pp.75-86). Hong Kong: The University Grants Committee of Hong Kong, Teaching Development Project.
- Tsai, C. W. & Chiang, Y. C. (2013). Research trends in problem-based learning (PBL) research in e-learning and online education environments: A review of publications in SSCI-indexed journals from 2004 to 2012. *British Journal of Educational Technology*, 44(6),185-190.
- *TuranTozo, A. (2011). *Türkiye'nin jeopolitiği ve bölgesel sorunları" konusunun problem dayalı öğrenme yöntemi ile öğrenci başarı ve tutumuna etkisinin değerlendirilmesi* [Assessing the effect of problem-based learning method on students' achievement and attitudes with the issue of "Turkey's geopolitical and regional problems"] (Unpublished master's thesis), Gazi University, Ankara.

- *Uslu, G. (2008). *Ortaöğretim Matematik dersinde problem dayalı öğrenmenin öğrencilerin derse ilişkin tutumlarına, akademik başarılarına ve kalıcılık düzeylerine etkisi*. [The effect of problem based learning to attitudes, success and level of permanence of the students in secondary school mathematics lessons], (Unpublished master's thesis), Balıkesir University, Balıkesir.
- *Uygun, N. (2010). *İlköğretim 5.sınıf Matematik dersinde problem dayalı öğrenmenin öğrencilerin derse ilişkin tutumlarına, akademik başarılarına ve kalıcılık düzeylerine etkisi* [The effect of the problem based learning on the attitudes, academic achievement and retention level of the 5th year ground school pupils in the mathematics course]. (Unpublished master's thesis), Gazi University, Ankara.
- 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.
- Ward, J. D., & Lee, C. L. (2002). A review of problem-based learning. *Journal of Family and Consumer Sciences Education*, 20(1), 16-26.
- *Yıldız, N. (2010). *Fen eğitiminde problem dayalı öğrenme senaryolarının çözümünde deney uygulamalarının öğrencilerin başarısına, tutumuna ve bilimsel süreç becerilerine etkisi* [The effect of experiment applications on the success, attitude and scientific process abilities of the students in the solution of the learning scenarios based on problems in science education]. (Unpublished master's thesis), Marmara University, İstanbul.

APPENDIX 1. Meta-Analysis Effect Coefficients and Summaries of Studies

Author(s)/ year of publication	Test Type	Study Code and Type	Field of study (Course)	Level of Education of the Sampling	Conceptual Subject	Period of Exp. (Week)	City of the study	Mean Effect Sizes of Studies and Confidence Intervals		
								ES	Lower Limit	Upper Limit
Tavukçu (2006)	A	T _{MT} -1	Science	Secondary	Genetics	8	Zonguldak	1,575	1,074	2,076
Karaöz (2008)	A	T _{MT} -7	Science and Tech.	Secondary	Force and Movement	6	Muşla	1,681	0,979	2,383
Uslu (2008)	A	T _{MT} -8	Mathematics	High	Possibility	3	Balıkesir	1,828	1,101	2,556
Sifoğlu (2007)	A-P	T _{MT} -12	Science	Secondary	Inheritance	4	Ankara	0,381	0,101	0,662
Tandoğan (2007)	A	T _{MT} -13	Science	Secondary	How do Objects React When Force is Applied?	10	İstanbul	0,633	0,074	1,093
Korucu (2007)	A-P	T _{MT} -15	Science	Secondary	Journey to the Inner Structure of Matter	5	Konya	-1,139	-1,697	-0,581
Koçak (2008)	A	T _{MT} -24	Geography	High	Demographic Properties of Turkey	4	İstanbul	1,152	0,494	1,810
Alagöz (2009)	A	T _{Pd} -26	Geography	University	Environment	9	Ankara	4,122	3,256	4,984
Şalgam (2009)	A	T _{MT} -36	Physics I	University	Newton's Laws of Movement	4	İzmir	1,270	0,775	1,766
Akın (2009)	A-P	T _{MT} -38	Mathematics	Secondary	Fractions	6	İzmir	0,581	0,012	1,149
Özsarı (2009)	A	T _{MT} -39	Mathematics	Primary	Natural Numbers and Measurement	10	İzmir	0,707	0,133	1,281
Kuşdemir (2010)	A	T _{MT} -47	Chemistry	High	Mixtures	9	Hatay	6,462	5,109	7,814
Çelik (2010)	A-P	T _{MT} -51	Science and Tech.	Secondary	Matter and Temperature	5	Ankara	0,625	0,016	1,233
Benli (2010)	A-P	T _{MT} -52	Science Lab.	University	Boiler Scale	8	Ankara	2,182	1,581	2,783

Şahin (2011)	A	T _{MT} -53	Physics	University	Electric Circuits	8	Erzurum	0,365	-0,082	0,812
Altunçekiç(2010)	A	T _{PHD} -54	Physics	University	Temperature and Heat	6	Ankara	0,987	0,458	1,517
Uygun (2010)	A-P	T _{MT} -55	Mathematics	Secondary	Environment and Area	6	Ankara	1,070	0,548	1,593
Yıldız (2010)	A	T _{MT} -57	Science and Tech.	Secondary	Granular Structure of Matter	8	İstanbul	0,486	0,040	0,932
Akın (2010)	A	T _{PHD} -58	English	University	Pre-intermediate Language Level	-	Ankara	2,254	1,498	3,010
Ayvacı (2011)	A	T _{MT} -61	Mathematics	Secondary	The Concept of Equation	10 ^{ch}	Kastamonu	0,183	-0,244	0,610
Özdil (2011)	A	T _{MT} -62	Mathematics	Secondary	The Area of Tetragonal Regions	16 ^{ch}	Kastamonu	0,417	-0,151	0,986
Çetin (2011)	A	T _{MT} -63	Life Sciences	Primary	The Theme “Yesterday, Today, Tomorrow”	6	İzmir	1,664	1,062	2,266
Tozo (2011)	A	T _{MT} -66	Geography	High School	Concepts on Regional Problems	4	Ankara	0,514	0,043	0,985
Moralı (2011)	A	T _{MT} -69	Science and Tech.	Secondary	Matter and Temperature	4	Edirne	1,296	0,587	2,005
Kaçar (2012)	A	T _{MT} -70	Science and Tech.	Secondary	Granular Structure of Matter	7	İzmir	3,021	2,182	3,861
Aka (2012)	A	T _{PHD} -71	General Chemistry-II	University	Acids and Bases	9	Ankara	1,790	1,281	2,299

T_{MT}: Master’s Thesis T_{PHD}: Doctoral Dissertation A: Academic Achievement Test P: Permanence Test ^{ch}: Course hour