

Full Length Research Paper

The effects of a problem based learning approach on students' attitude levels: A meta-analysis

Veli Batdı

Cumhuriyet Anatolian High School, 23300, Elazığ/Turkey.

Received 26 February, 2014; Accepted 22 April, 2014

This research aimed to examine the effect of a problem-based learning approach in comparison to traditional learning approaches. In this context, the question "What is the effect size of problem-based learning on students' attitudes?" was tried to be answered. Among 190 studies made in national and international field between the years 2006 to 2013, 19 theses and 6 articles, in which pre-test and post-test experimental design was applied, were examined in this meta-analysis according to inclusion criteria. As a result of analytic evaluation, the effect size value of the problem-based learning on attitudes in relation to a random effects model was measured to be 0.7195. Thus, it can be said that this value had a medium effect size according to the classification levels of Thalheimer and Cook. It was concluded from these results that problem-based learning approaches were more effective when compared to traditional teaching techniques.

Key words: Problem-based learning, effectiveness, meta-analysis, effect size, traditional teaching.

INTRODUCTION

Problem based learning, is a learning process in which there are active students who can produce new information by using existing knowledge (Major and Palmer, 2001). It is a well-developed approach used in education and is applied extensively nowadays (Hmelo-Silver, 2004: 236). Borrow (1984) personally began the process of improving problem based learning in Canada, at McMaster University. Borrow described this approach as being student-centered, teachers' taking lesson in small groups, in which they take a facilitative role, and organizing the lesson within the framework of various problems (cited in Graaff and Kolmos, 2003).

However, Barrett (2010) has explained problem based learning as a situation in which learners' struggle for a solution within the framework of certain problems that

have been carried out independently or as group discussions and controlled by a teacher. Problem based learning, as well as analyzing theory, model and application steps, has been especially focused upon application step. The reason for this is that there are many processes applied in universities such as Linko Ëping, Maastricht, Roskilde and Aalborg, in the formation of related learning approaches (Graaff and Kolmos, 2003). So it can be said that a problem based learning approach is especially related to the field of application and makes students attain learning goals within the framework of several problems.

Problem based learning transforms learners into active independent learners instead of passive information receivers (Akinođlu and Tandođan, 2007). This is an

E-mail: veb_27@hotmail.com Tel: +90 (505)504-8814.

Author agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

approach which aims at noticing the importance of problems encountered in real life circumstances by recognizing them. This process searches for the reasons for these problems and seeks solutions and predicts other problems and aims to prevent them. So it is a question of starting off a problem by making information a major target and searching for the solution to a problem (Chin and Chia, 2004). Within the context of problem based learning the aim is not only to achieve an analysis of a specific subject but also to determine new learning targets and ensures the learners acquire problem solving, questioning, research and critical skills (Major and Palmer, 2001).

Dolmans (1994) has underlined that it is an approach which encourages independent and self-directed learning by ensuring a process in which learning targets are transferred to a problem, students analyze this problem in small group discussions. The major principles and processes emphasized in the problem are assessed, and questions of which answers can be attained are researched in group discussions described as learning subjects (cited in Davis and Harden, 1999). For this reason, we can describe problem based learning as an approach which does not simply find a solution to a problem, but also expresses it as an approach in which problems are used to ease learning (Awang and Ramly, 2008) by identifying and analyzing existing problems to find a solution as a result of collaborative studies among students (Peterson, 1997) In this way, it predicts that students will show a better learning performance and consequently more positive attitudes towards lessons (Forrester, 2004). In this regard, it is understood that problem based learning has a positive effect on students attitudes towards lessons.

Much research has been performed regarding problem based learning by assessing the students results and the increases in learners' success (Awang and Ramly, 2008; Colliver, 2000; Yoon et al., 2014) and an improvement in attitudes towards lessons (Demirel and Turan, 2010; Selçuk, 2010). There has been an effort to examine problem based learning which has helped learners to develop more creative, critical, disputative and problem solving skills and that supports learning activities which has to be done voluntarily.

METHODOLOGY

Data collection

In this research, a meta-analysis method was used, which is described as a way to reach a general conclusion by putting together and re-analyzing the results of different studies. These are studies carried out concerning the same subject but collected independently from each other in order to specify the level of the effect of problem based education approach on students' attitude levels (Glass, 1976). Collected from national and international area (Google scholar, council of higher education national thesis center, ebscohost-eric, sciencedirect) 73 articles and 117 theses in total which applied pretest-posttest control group model, examining the

effects of problem based learning approaches to attitude, having sample size (n), arithmetic average (X), and standard deviation (sd) values were examined and among these studies, 25 ones (6 articles and 19 theses) have been chosen for meta-analysis, by taking into account the suitability of inclusion criteria between 2006 and 2013. On the other hand, as study characteristics, the educational level of students attending the study, lessons in which the process was applied, publication type and the year of publication that study belonged to, sample size of studies, standard deviation and the mean values of samples, were determined.

Data analysis

In the data analysis process, the effect of the meta-analysis method which includes calculations of the average differences between the experimental group and control group was tried to be determined (Hunter and Schmidt, 1990: cited in Şahin, 2005). In this research, the effect size "d" value which is obtained as a result of the division of difference of averages between the experimental group and the control group to total standard deviation (Cohen, 1992) was calculated according to Thalheimer and Cook's (2002) level classification. For analysis of the effect coefficient analysis calculated for each study, fixed effects model (FEM) and random effects model (REM) interpretations were made by taking these into consideration. CMA (Comprehensive meta analysis), the MetaWin statistical program and Microsoft excel 2010 Office programs were used.

FINDINGS

In this research, as a result of a literature review of 18 masters' degree, a PhD theses and 6 articles which gave their arithmetic averages and standard deviations related to problem based learning, a total of 25 studies concerning problem based learning efficiency on attitudes were found. Moreover the experimental groups comprised of 680 students and the control group 689 students. At this point a homogenous distribution value, average effect size and confidence interval for effect models regarding attitude points of studies were included in the analysis and were given in Table 1. As can be seen in Table 1, according to the fixed effect model, data from the theses included in the meta-analysis were calculated as; 0,054 standard deviation, 0,7195 upper limit and 0,4881 sub-limit of the %95 confidence interval with an effect size value of ES=0,6038. When statistical significance was calculated according to the z-test, the value was found as being 13,463 (p=0,0000). As a result of meta-analysis Q-statistics homogeneity test values were calculated as being 138, 3342.

In the chi-square table at the %95 significance level with 24 degrees of freedom, the critical value was seen to be found as 36.415. According to the fixed effects model, the Q statistics homogeneous test value of the data in 25 studies were rejected with its 24 degrees of freedom, as it exceeded a critical value, in the homogeneity of the fixed effects model which refers to the range of effect levels.

As the homogeneity test of the research included in the study was higher than expected, the model was transformed into a random effects model by calculating the

Table 1. Homogeneous distribution values, average effect sizes and confidence intervals in effect models of studies included in meta-analysis

Type of model	n	Z	p	Q	df	ES	% 95 Confidence Intervals	
							Lower	Upper
FEM	25	13,463	0,00000	138,3342	24	0,6038	0,4881	0,7195
REM	25	4,563	0,17540	30,2876	24	0,7195	0,4391	0,9999

Table 2. Effect sizes of studies according to the teaching grades and application durations

Teaching Grades	N	ES	% 95 Confidence Intervals		Application Duration	N	ES	% 95 Confidence Intervals	
			Lower	Upper				Lower	Upper
Secondary	14	0,543	0,080	1,006	2 to 4	6	0,864	0,322	1,405
High	5	1,506	0,865	2,147	5 to 8	9	0,477	-0,204	1,158
University	5	0,536	-0,008	1,081	Unspecified	6	0,991	0,265	1,718
Total	24	0,767	0,494	1,039	Total	21	0,770	0,545	0,995
Q=6,690 Z=5,514 df=3 p=0,082				Q=1,186 Z=6,719 df=3 p=0,756					

random effect component of variance. As a result of the calculations, when the data of 25 studies included in meta-analysis were examined according to random effects model, 0,163 standard deviation and 0,9999 upper limit and 0,4391 sub-limit of the %95 confidence interval with an effect size value as ES=0,7195 were found. This result therefore favored the use of a problem based approach in the learning environment. Moreover, as in many studies the effect size value was between 0,2368 and 2,5771, according to Thalheimer and Cook (2002) the results of these studies had all effects of negligible, small, medium, large, very large and huge levels.

The efficiency of problem based learning according to teaching grades and application durations of the studies included in meta-analysis

Studies were divided into 4 different groups to determine samples' learning level effects, which were included in the meta-analysis, of the total effect size. In Table 2 the results of the homogeneity test, Q statistical value was calculated as 690 according to the analysis results. In the chi-square table at the %95 significance level with 3 degrees of freedom, the critical value was accepted to be about 7.815. As the Q statistical value calculated in the research (6,690) was smaller than the critical value 7.815, the homogeneity hypothesis belonging to effect size distribution was accepted in a fixed effect model.

In addition to the data shown in Table 2, one study at the level of primary school (ES= 0,773) and four studies for the 9-18 week group (ES= 0,761) were included in the analysis. When the effects of problem based learning approaches usage in learning environment on application

duration were examined as a result of the homogeneity test, Q statistical value was calculated as 1,186. In the chi-square table, at the significance level of %95 with 3 degrees of freedom, the critical value was accepted as being about 7.815. As the Q statistical value (1,186) was calculated in the research as being smaller than the critical value 7.815, the homogeneity hypothesis belonging to effect sizes distribution was accepted in the fixed effect model.

RESULTS AND DISCUSSION

In this meta-analytic study, it has been concluded that the problem based learning approach has been used frequently in teaching of different lessons and subjects in teaching environment, and that this approach has had a positive effect on the students' attitude. To identify the effect of a related approach to attitude points, the general effect size calculated according to an applied random effect model has been found as being 0,7195. This value shows that problem based learning is more efficient than traditional learning methods in terms of effects on attitude. This effect size can be said to be at a medium level according to the classification of Thalheimer and Cook (2002).

In this meta-analytic evaluation, the effect size was differentiated on the basis of whether or not the teaching levels, under which studies were performed, have been included in the analysis. In terms of teaching levels, effect sizes have taken positive values at three levels; secondary school, high school and university; and while the greatest effect has been observed in secondary school, the lowest was observed in high school. At the three teaching levels, the total efficiency level of problem based

learning ($ES=0,767$) takes place in a wide range according to Thalheimer and Cook's (2002) classification. On the other hand, as for teaching levels it can be said that there isn't a significant difference in terms of effect sizes and problem based learning's effect in terms of attitude hasn't changed according to teaching levels. Similar to this study, a meta-analytic study has searched whether the related approach has differed in terms of efficiency level according to teaching grades for different subjects in the past in Turkey (Şahin, 2005; Camnalbur and Erdoğan, 2008) and in related studies it has been determined that effect sizes haven't differentiated according to the teaching level.

When application duration is examined in studies related to the effect size of the problem based learning, studies' application durations have been separated into three groups, 2 to 4 weeks, 5 to 8 weeks and unspecified. According to this analysis, the highest effect size with 0,991 has been seen in the studies in which the application duration is unspecified and the lowest effect size was seen in 5 to 8 weeks group with 0,477. Groups' total effect size has been found to be 0,767. This level takes place in wide range according to Thalheimer and Cook's (2002) classification. When the homogeneity test between groups examined, a value of $Q_B=1,186$ has been found. This result shows that there isn't a meaningful difference according to their application duration when the studies included in the meta-analysis were grouped according to their application durations and their effect sizes were examined ($Q_B=1,186$; $p=0,756$). In addition to this, save for the 9 to 18 week group, all other groups' effect sizes showed positive values in terms of application duration. Data belonging to the 9-18 weeks group were obtained from only 4 encounters. It can be said that it isn't acceptable to generalize this effect size to 9 to 18 week groups and that this only gives information about the current situation. Therefore it can be categorically stated that more experimental studies should be performed worldwide so as to generalize analysis results to the related groups. In Öner Armağan's (2011) study about the efficiency of notional change text, no difference has been found in terms of the effect size in accordance with the analysis results of the application duration ($Q_B=2.362$; $p=.306$). This finding can be interpreted as demonstrating that this study includes parallel results as the related groups' study results.

When the findings of the studies were examined, it was observed that there is a meaningful difference between the experimental group in which problem based learning observed and the control group in which traditional methods were used, in terms of attitude levels towards related lesson after experimental process. This situation has been emphasized in different studies included in a meta-analysis (Karaöz, 2008; Akın, 2009). In other words, it can be said that the teaching environments which are prepared with regard to problem based learning approaches have enhanced the students' attitude in the different lessons. These findings demonstrate that there

is a meaningful difference in favor of the experimental group in terms of attitude averages. These results were shown in these domestically and in different articles internationally in a similar way (Tüysüz et al., 2010; Günbatar and Çavuş, 2011; Tsenga et al, 2012).

This meta-analysis assessed cases in which a student-centered problem based learning approach is used. In most of the studies it has been emphasized that related approaches have given rise to more positive results in terms of students' attitude towards lessons regarding classes in which traditional learning environments were used. For this reason, to allow students to develop a positive attitude towards lessons, we suggest that a student-centered approach such as problem based learning is applied in the lessons.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

- Akın P (2009). The effects of problem-based learning on students' success in the teaching the topic fractions at the 5th grade. Unpublished Master's thesis, Ege University, Social Sciences Institute, Izmir.
- Akinoğlu O, Özkardeş TR (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia J.Math., Sci.Tech. Educ.* 3(1):71-81.
- Awang H, Ramly I (2008). Creative thinking skill approach through problem-based learning: pedagogy and practice in the engineering classroom. *International J. Human ,Social Sci.* 3(1):18-23.
- Barrett T (2010). The problem-based learning process as finding and being in flow. *Innovations in Education and Teaching International*, 47(2), 165-174.
- Camnalbur M, Erdoğan Y (2008). A Meta analysis on the effectiveness of computer-assisted instruction: Turkey sample. *Educational Sciences: Theory Practice*, 8:497-505.
- Chin C, Chia L (2004). Problem-based learning: using students' questions to drive knowledge construction. *Science Education*, 88:707-727.
- Cohen J (1992). Statistical power analysis. *Current Directions in Psychol. Sci.* 1(3):98-101.
- Colliver JA (2000). Effectiveness of problem-based learning curricula: Research and Theory. *Academic Medicine* 75(3):259-266.
- Davis MH, Harden RM (1999). Problem-based learning: A practical guide. *Medical Teacher* 21(2):130-140.
- Demirel M, Arslan Turan B (2010). The effects of problem based learning on achievement, attitude, metacognitive awareness and motivation. *Hacettepe University J. Educ.*38:55-6.
- Forrester V (2004). Problem-based Learning: a Problem with Education? *Hong Kong Teachers' Centre J.* 3:48-55.
- Glass GV (1976). Primary secondary and meta-analysis of research. *Educ. Res.* 5(10):3-8.
- Graaff E, Kolmos A (2003). Characteristics of problem-based learning. *Inter. J.Eng. Educ.* 19(5):657-662.
- Günbatar MS, Çavuş H (2011). Student's attitudes relating to web mediated problem based learning. *Ankara University, J. Faculty Educ. Sci.* 44(2):119-140.
- Hmelo-Silver CE (2004). Problem-based learning: what and how do students learn? *Educ. Psychol. Rev.* 16(3):235-266.
- Major CH, Palmer B (2001). Assessing the effectiveness of problem based learning in higher education: Lessons from the literature. *Academic Quarterly* 5(1).

- Öner Armağan F (2011). Effectiveness of Conceptual Change Texts: Meta Analysis. Unpublished PhD thesis, Gazi University, Education Faculty, Ankara.
- Peterson M (1997). Skills to Enhance Problem-based Learning. *Med Educ Online* [serial online] 1997; 2,3. Available from: <https://www.msu.edu/~dsolomon/f0000009.pdf>
- Şahin MC (2005). The effectiveness of Internet-based distance education: a meta-analysis study. Unpublished Master's thesis, Çukurova University, Social Sciences Institute, Adana.
- Thalheimer W, Cook S (2002). How to calculate effect sizes from published research articles: A simplified methodology. http://www.bwgriffin.com/gsu/courses/edur9131/content/Effect_Sizes_pdf5.pdf
- Tsenga KH, Changb CC, Lou SJ (2012). The process, dialogues, and attitudes of vocational engineering high school students in a web problem-based learning (WPBL) system. *Interactive Learn. Environ.* 20(6):547-562.
- Tüysüz C, Tatar E, Kuşdemir M (2010). The 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.
- Yoon H, Woo AJ, Treagust D, Chandrasegaran AL (2014) The Efficacy of problem-based learning in an analytical laboratory course for preservice chemistry teachers. *Int. J. Sci. Educ.* 36(1):79-102, DOI:10.1080/09500693.2012.727041.

Citations

(The symbol of * refers to the studies included in the meta-analysis).

- *Aka İE (2012). The effect of problem-based learning method used for teaching acids and bases on different variables and students' views on the method. Unpublished PhD thesis, Gazi University, Education Sciences Institute, Ankara.
- *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's thesis, Gazi University, Education Sciences Institute, Ankara.
- *Çelik E (2010). 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, Education Sciences Institute, Ankara.
- *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.
- *Gök T, Sılay, İ (2008). Effects of problem-solving strategies teaching on the problemsolving attitudes of cooperative learning groups in physics education. *J.Theory,Practice in Educ.* 4(2), 253-266.
- *Gürten E (2011). The effect of problem based learning on learning outcomes, problem solving skills and self-efficacy. *Hacettepe University J. Educ.* 40:221-232.
- *Karadaş A (2010). Effect of the problem based learning applied to student achievement in biochemistry to "coenzyme" issue. Unpublished Master's thesis, Dokuz Eylül University, Education Sciences Institute, Izmir.
- *Kayıpmaz AÇ (2011). The effects on the learning outcomes of problem based learning in science instruction the effects of problem based learning on primary school 5th grade students' attitudes toward reading. Unpublished Master's thesis, Afyon Kocatepe University, Education Sciences Institute, Afyonkarahisar.
- *Koçak M (2008). 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, Education Sciences Institute. İstanbul.
- *Korucu EN (2007) Comparing with problem and cooperative based learning method applied in primary schools on the success of the students. Unpublished Master's thesis, Selçuk University, Institute of Science, Konya.
- *Kuşdemir M (2010). An analyze of the effect of problem based learning model on the students success, attitude and motivations Unpublished Master's thesis, Mustafa Kemal University, Social Sciences Institute, Hatay.
- *Moralı A (2011). The effect of Problem-based learning approach, on academic achievement, attitude and motivation. Unpublished Master's thesis, Thrace University, Institute of Science, Edirne.
- *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's thesis, Kastamonu University, Social Sciences Institute, Kastamonu.
- *Özkardeş Tandoğan R (2007). 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, Education Sciences Institute, İstanbul.
- *Özşarı T (2009). The effect of cooperative learning method to the fourth grade student' achievement on mathematic learning: problem based learning (PBL) and student teams- achievement division methods (STAD). Unpublished Master's thesis Ege University, Social Sciences Institute, Izmir.
- *Pakyürek Karaöz M (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's thesis, Muğla University, Institute of Science, Muğla.
- *Şalgam E (2009). The Effect of Problem Based Learning Method on Students' Academic Achievement and Their Attitude on Physics Education. Unpublished Master's thesis, Dokuz Eylül University, Education Sciences Institute, Izmir.
- *Tavukçu K (2006). The effects on the learning outcomes of problem based learning in science instruction. Unpublished Master's thesis, Zonguldak Karaelmas University, Social Sciences Institute, Zonguldak.
- *Turan Tozo, A. (2011). Evaluating the effect of problem-based learning on students' academic success and attitude related to geopolitics and regional issues of Turkey. Unpublished Master's thesis, Gazi University, Education Sciences Institute, Ankara.
- *Uygun N (2010). 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, Education Sciences Institute, Ankara.
- *Yıldız N (2010). The effect of experiments 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, Education Sciences Institute, İstanbul.