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Research Article

The Effect of Brain Based Learning on Academic Achievement and Students' Attitude in Turkey: A Meta Analytical Study

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Abstract

Brain Based Learning approach is a new and promising trend in education, therefore researchers provide increasing data about its effects in real life. In this meta-analysis study, data from studies investigating the effect of Brain Based Learning on academic achievement and students' attitude in Turkey were combined to reveal the effectiveness of Brain Based Learning. For this purpose, experimental studies (40 about academic achievement and 25 about students' attitude) published between 2005 and 2015, in Turkey and meeting the inclusion criteria were analysed by treatment effectiveness meta-analysis method. Effect sizes were calculated according to Hedges's g. In addition, the effect size values of Brain Based Learning on academic achievement and on students' attitude were compared in terms of study type and study year. As a result, we concluded that Brain Based Learning has a positive and large effect on academic achievement and a positive but moderate effect on students' attitude. We also found that the effect size values of Brain Based Learning on both academic achievement and students' attitude do not change by type or year of the study.

Key Words

Brain based learning • Brain-compatible learning • Academic achievement • Attitude • Meta-analysis

* This research is based on the first author's master's thesis.

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Developing technology changes the way people live, think and eventually learn continuously. Traditional educational methods fail to adapt to this changing world, thus new approaches are required. Neuroscience provides valuable information on brain structure, function and cognitive behaviour. As a reflection of neuroscientific evidences, a new approach called "Brain Based Learning" (BBL) emerged in the field of education.

Brain Based Learning is the recognition of the brain's codes for a meaningful learning and adjusting the teaching process in relation to those codes (Caine & Caine, 2002). BBL is a learning approach that is related to neuroscience, neurolinguistics and cognitive psychology and that is based on the structure and functions of the human brain. By traditional teaching methods students tend to memorize rather than learning because natural learning process of the brain is ignored. Students using BBL strategies perform meaningful learning at full level and construct their own knowledge (Demirel, 2010). BBL is a way of thinking about learning (Duman, 2015). To sum up, Brain Based Learning is an approach that aims to realize learning in a meaningful way by understanding and simulating the structure and functional mechanisms of the brain.

The main objective in Brain Based Learning is to enhance learning and teaching. Students are encouraged to concentrate on learning and to accumulate experiences. Meaningful learning is obtained through 3 phases: relaxed alertness, orchestrated immersion and active processing (Caine & Caine, 2002).

Brain Based Learning has twelve basic principles which are i. Brain processes multiple data simultaneously like a parallel circuit , ii. Learning is about using all of the body and physiology, iii. The search for meaning is a natural phenomenon, iv. The search for meaning happens through patterning, v. Emotions play important role for patterning, vi. Parts and wholes are processed simultaneously in the brain, vii. Learning requires focused attention along with peripheral attention, viii. Learning involves both conscious and unconscious processes, ix. There are at least two types of memory systems: spatial and rote learning, x. Facts and skills are best understood and learnt when they are adapted into the natural spatial memory, xi. Challenging promotes and threats inhibit learning, xii. Each brain is unique on its own (Caine & Caine, 2002). Since these principles explain the conditions under which learning takes place in the brain, they provide a theoretical framework in teaching and learning processes and provide guidance to educators in setting the environment and selecting appropriate methods and techniques (Sadık, 2013).

When searching the literature, there was limited study examining the effect of Brain based learning on academic achievement by meta-analysis. In addition, no meta-analysis study was found to reveal the effect of Brain Based Learning on students' attitude. The aim of this meta-analysis study is to combine the results of the studies where 2 groups (BBL applied group vs non applied) were compared to show how effective the Brain based learning was on academic achievement and students' attitude. For this purpose, 40 studies related to academic achievement and 25 studies related to attitude were included in the meta-analysis and the answers to the following questions were sought:

- Does Brain Based Learning have a positive effect on students' academic achievement?
- Is there a significant difference in the effect sizes of Brain Based Learning on academic achievement in terms of the year of study?

- Is there a significant difference in the effect sizes of Brain Based Learning on academic achievement in terms of the type of study?
- Does Brain Based Learning have a positive effect on students' attitude?
- Is there a significant difference in the effect sizes of Brain Based Learning on students' attitude in terms of the year of study?
- Is there a significant difference in the effect sizes of Brain Based Learning on students' attitude in terms of the type of study?

Method

Data Collection Process

The model of this study is meta-analysis which is one of the literature survey methods. First step is the literature search. By using keywords "brain, learning, brain based learning, meta-analysis, attitude, academic success" in Turkish we found 605 articles on Google Scholar, 25 articles on Ulakbim databases, 38 articles on YÖK Academic and 54 theses on YÖK National Thesis Centre. If not available online, we collaborated with libraries and authors. For studies published both as an article and as a thesis, only the thesis type is included in the meta-analysis, since it contains more detailed data to avoid duplication. Some studies consisted of more than one experimental or control groups, as a technical issue, we considered them as separate studies and labelled as a and b. Inclusion criteria were studies as master thesis, doctorate thesis or articles being published in Turkey between 2005 and 2015 in Turkish language, designed as an experimental group of Brain Based Learning method applied students versus a non-applied control group and in which means, standard deviation values and sample sizes can be identified. As a result, 40 studies on academic achievement and 25 studies on students' attitude were eligible to be included in the meta-analysis.

Coding

After determining suitable studies, we created a detailed and specific coding method to indicate their differences (Camnalbur, 2008). In the coding form descriptive information such as the number, name, year, author, source, type, date of the study as well as the course name and academic grade where the BBL is used is indicated, and study data is presented.

Research Model

Meta-analysis combines and analyses research findings by converting the data from multiple different studies into a summary estimate value called effect size, also called effect coefficient (Dinçer, 2014; Durlak, 2003). The standard deviation, means, t, F or r values of the studies can be combined by specific formula to obtain the effect size. (Rossenthal, 1991, as cited in Kaşarci, 2013). In this study we used the most common and simplest group contrast meta-analysis type which is the treatment effectiveness meta-analysis. The standardized effect size indicated by the letters "d" or "g" is the difference between the means of the experimental group and control group divided by the

total standard deviation ($X_e - X_c$/ S*pooled*). In this formula, X_e refers to the experimental group's mean score, X_c refers to the control group's mean score, and S*pooled* refers to the pooled standard deviation value (Şahin, 2005).

When combining the results of the studies in the meta-analysis there are two statistical models. If the study population is identical and the standard deviation is zero, it is assumed that the studies have one real effect thus the Fixed Effects Model should be used. When the population sizes are different and the standard deviation is not equal to zero, studies can be combined with certain transformations, the Random Effects Model should be used (Dinçer, 2014). The funnel graph, Q or p values are used to determine the homogeneity or heterogeneity of the study populations and to choose the appropriate model (Dinçer, 2014).

We used Comprehensive Meta-Analysis version 3 (CMA V.3) software to calculate the effect sizes according to Hedges's g. We obtained the funnel graphs and Q and p values. Considering these findings, we used appropriate model either Random Effects Model or Fixed Effects Model for the general and subgroup analysis. According to Cohen, Welkowitz and Ewen's (2000) classification, effect size value of 0.20 means small, 0.50 means medium and 0.80 means large effect. Statistically significant refers to $p<0.05$.

Findings

General Effect Size Results Related to Academic Achievement

In this meta-analysis 2 article, 26 master thesis and 12 doctoral thesis on academic achievement are included. The studies included in this meta-analysis were combined into effect sizes with standard error and minimum value and maximum value. Table 1 presents the ununited findings of the effect sizes calculated for academic achievement.

Table 1

Ununited Findings of the Effect Sizes of the Studies (Academic Achievement)

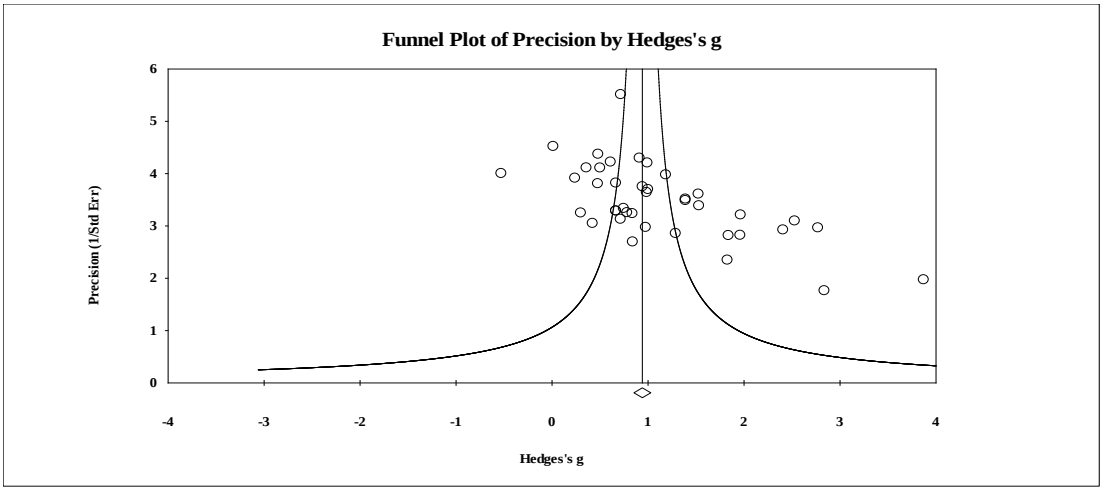
Study name	Effect size value Hedges's g	Standard error	Min. value	Max. value
Özden, 2005	0,786	0,308	0,183	1,389
Tüfekçi, 2005a	0,916	0,233	0,459	1,372
Tüfekçi, 2005b	0,017	0,221	-0,417	0,451
Çengelci, 2005	0,719	0,320	0,091	1,346
Avcı, 2007a	0,947	0,267	0,423	1,470
Avcı, 2007b	1,395	0,285	0,837	1,953
Hasra, 2007	1,969	0,312	1,358	2,580
Baştuğ, 2007a	0,244	0,256	-0,258	0,745
Baştuğ, 2007b	0,670	0,262	0,156	1,184
Öner, 2008	0,481	0,263	-0,034	0,997
Usta, 2008	1,535	0,296	0,956	2,115
Çelebi, 2008	0,363	0,244	-0,115	0,840
Aydın, 2008	0,670	0,305	0,073	1,267
Yağlı, 2008a	0,304	0,308	-0,300	0,908
Yağlı, 2008b	0,427	0,328	-0,217	1,071
Demirhan, 2010	-0,525	0,250	-1,015	-0,035
İnci, 2010	1,832	0,427	0,995	2,668
Yıldırım, 2010	0,845	0,372	0,117	1,574
Görgün, 2010	2,775	0,338	2,113	3,437
Yücel, 2011	2,411	0,342	1,740	3,083

Akyürek, 2012a	1,293	0,351	0,606	1,980
Akyürek, 2012b	0,980	0,337	0,320	1,641
Palavan, 2012	0,721	0,182	0,365	1,077
Albayrak, 2012	1,965	0,355	1,269	2,660
Eyüp, 2013	1,530	0,277	0,986	2,073
Ermurat, 2013	0,670	0,305	0,073	1,267
Hiçyılmaz, 2013	3,876	0,508	2,880	4,872
Sadık, 2013	0,505	0,244	0,028	0,983
İnci, 2014a	0,615	0,237	0,150	1,080
İnci, 2014b	1,190	0,252	0,697	1,683
Esen, 2014a	1,843	0,356	1,146	2,539
Esen, 2014b	0,751	0,300	0,163	1,339
Çakıroglu, 2014	2,532	0,323	1,898	3,166
Canbulat, 2014a	0,485	0,229	0,036	0,934
Canbulat, 2014b	0,998	0,238	0,531	1,464
Bozbağ, 2015	0,842	0,309	0,235	1,448
Baş, 2010	1,005	0,271	0,474	1,535
Süral, 2014	0,991	0,275	0,451	1,530
Peder, 2009	1,395	0,287	0,832	1,958
Yaman, 2014	2,841	0,569	1,726	3,956

Table 1 shows that the greatest effect in individual studes belongs to the study titled “Hiçyılmaz, 2013” and the smallest effect belongs to “Tüfekçi, 2005b”. Also, the table presents that 39 of the studies have positive and 1 study has negative effect size. According to this result, it can be said that most of the studies have positive effect on academic achievement. In other words, the performance is in favor of experimental groups.

In order to select the model, we will use in meta-analysis for calculating the effect sizes, we need to do a heterogeneity test or draw a funnel graph. Firstly, we drawn the funnel graph. In figure 1, the distribution of effect sizes of the studies according to Hedges’s g is shown as funnel plot of precision.

Figure 1. Distribution of the Effect Sizes of the Studies by Hedges’s g (Funnel Graph)



When we examine the funnel graph in Figure 1, we can see that all of the studies are not within the slope line. Therefore, we can say that the studies are heterogeneous. Secondly, we need to do a heterogeneity test to be sure. Table 2 shows the heterogeneity test values of the studies included in the study.

Table 2

Heterogeneity Test Values of the Studies (Academic Achievement)

Q value	df(Q)	p value	I-squared
251,399	39	0,000	84,487

According to table 2, the Q value is 251,399 and the p value is 0,000. For significance level of 95%, for 39 degree of freedom critical value is found as 54,57223. If the Q value is smaller than the df (Q) value in the table, the study is interpreted as homogeneous and if Q value is bigger than df (Q) value the study is heterogeneous (Dinçer, 2014). In addition, if the p value is smaller than the referenced confidence interval coefficient, the study is homogeneous and if p is larger, the study is heterogeneous. Statistical value of Q=251,399 is bigger than the degree freedom value of 39. Also, p=0,000 and it is smaller than the references value (0,05). According to these results the study is heterogeneous, so we used the Random Effects Model. Table 3 shows the total effect size values of the studies according to the models.

Table 3

Total Effect Size Values of the Studies by Models (Academic Achievement)

Model	Effect size Value Hedges's g	Standard error	Min. value	Max. value
Random Effects Model	1,095	0,116	0,868	1,321
Fixed Effects Model	0,941	0,045	0,853	1,029

From the table 3, we can see that the total effect size value is d=1,095 according to the Random Effects Model, this value indicates a large effect. We concluded that BBL has a positive and large effect on students' academic achievement.

Results Related to the Effect Sizes by Year of Study (Academic Achievement)

As a result of the heterogeneity test the $Q_B$value is 9,540 and p value is 0,145. In chi- square table with CI of 95% and for 6 degree of freedom the critical value is found as 12,592. Since the calculated value is smaller than the critical value and the p value is greater than 0.05, the groups are homogeneous, so we used Fixed Effects Model. Results are summarised in Table 4.

Table 4

Effect Size Values by Year of Study (Academic Achievement)

Study year	Number of works	Effect size	Lower limit	Upper limit
2005	4	0,550	0,295	0,805
2007	5	0,966	0,725	1,206
2008	6	0,614	0,385	0,843
2010	5	0,896	0,622	1,170
2012	4	1,026	0,762	1,289
2013	4	1,137	0,844	1,431
2014	9	1,090	0,908	1,273
Total	37	0,904	0,813	0,995

According to Table 4, the total effect size value is 0.904, the largest effect size value belongs to year 2013 and the smallest effect size value belongs to year 2005. We concluded that there is no significant difference in the effect sizes of the BBL on students'academic achievement in terms of the year of study.

Results Related to the Effect Sizes by Type of Study (Academic Achievement)

As a result of the heterogeneity test the $Q_B$value is 1,192 and p value is 0,551. In chi- square table with CI of 95% and for 2 degrees of freedom the critical value is found as 5,991. Since the calculated value is smaller than the critical value and the p value is greater than 0.05, the groups are homogeneous, so we used Fixed Effects Model and results are presented in Table 5.

Table 5

Effect Size Values by Type of Study (Academic Achievement)

Study type	Number of works	Effect size	Lower Limit	Upper Limit
PhD thesis	12	0,841	0,700	0,982
Article	2	0,998	0,619	1,376
Master thesis	26	1,005	0,887	1,122
Total	40	0,941	0,853	1,029

We can see that the total effect size value is 0.941, the largest effect size value is in the master's thesis type and the smallest effect size value is in the PhD thesis type. But in conclusion there is no significant difference in the effect sizes of the BBL on students'academic achievement in terms of the type of study.

General Effect Size Results Related to Students' Attitude

One article, 15 master thesis and 9 doctoral thesis showing the effect of BBL on students' attitude are included in the meta- analysis. Table 6 presents the ununited findings of these studies.

Table 6

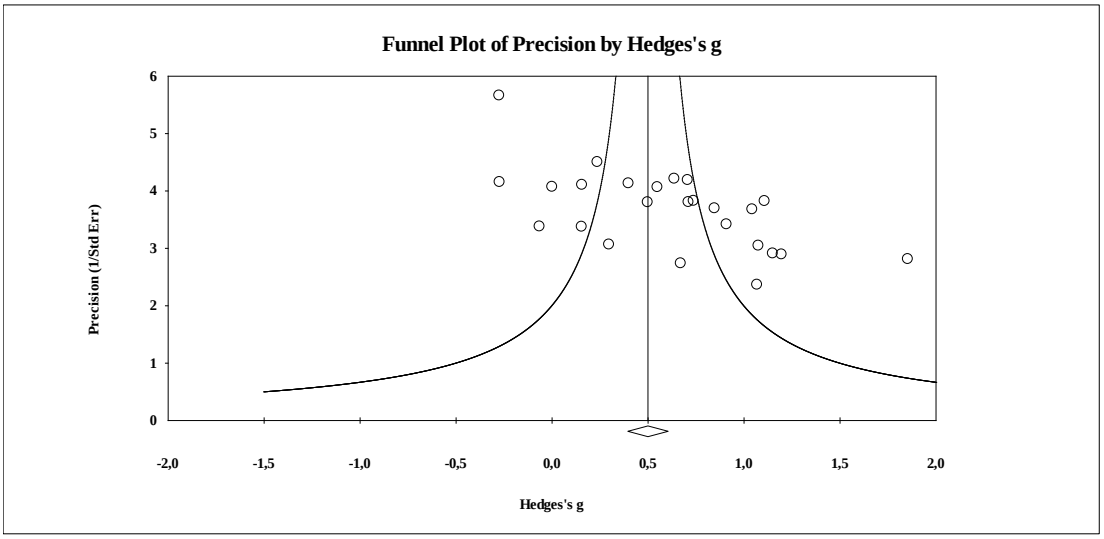
Ununited Findings of the Effect Size of the Studies (Attitude)

Study name	Effect size value Hedges's g	Standard error	Min. value	Max. value
Tüfekçi,2005	0,238	0,222	-0,197	0,674
Avcı, 2007a	0,739	0,262	0,227	1,252
Avcı, 2007b	0,712	0,263	0,197	1,228
Öner,2008	0,500	0,263	-0,016	1,016
Çelebi,2008	0,551	0,246	0,068	1,033
Aydın,2008	0,158	0,244	-0,320	0,636
Yağlı,2008 a	1,077	0,329	0,433	1,721
Yağlı, 2008b	0,298	0,327	-0,342	0,938
Yıldırım,2010	0,672	0,366	-0,045	1,389
Yücel,2011	0,848	0,271	0,318	1,379
Akyürek,2012a	1,152	0,344	0,477	1,826
Akyürek,2012b	1,197	0,346	0,519	1,876
Palavan,2012	-0,274	0,177	-0,620	0,073
Eyüp,2013	1,109	0,262	0,596	1,622
Ermurat,2013	0,156	0,297	-0,425	0,738
Hiçyılmaz,2013	1,855	0,356	1,157	2,553
Sadık,2013	0,400	0,242	-0,075	0,875

İnci,2014 a	0,639	0,238	0,173	1,104
İnci,2014 b	0,709	0,239	0,240	1,177
Çakıroğlu,2014	-0,272	0,241	-0,744	0,201
Bozbağ,2015	-0,064	0,296	-0,644	0,517
Kibaroğlu,2015	0,911	0,293	0,337	1,485
Baş,2010	1,045	0,272	0,511	1,578
Yaman,2014	1,070	0,423	0,240	1,899
Demirhan,2010	0,002	0,246	-0,480	0,484

The greatest effect in individual studies belongs to the study titled "Hiçyılmaz, 2013" and the smallest effect belongs to "Demirhan, 2010" study. Also, the table shows that 22 of the studies have positive and 3 studies has negative effect size. In other words, in most of the studies BBL had a positive effect on students' attitude. For selecting the meta- analysis model, we drew a funnel graph like in Figure 2.

Figure 2 Distribution of the Effect Sizes of the Studies by Hedges's g (Funnel Graph)



When we examine the funnel graph it can be said that the studies are heterogeneous. We also performed heterogeneity tests and presented findings in Table 7.

Table 7

Heterogeneity Test Values of the Studies (Attitude)

Q value	df(Q)	p value	I-sguared
85,297	24	0,000	71,863

Table 7 shows that, the Q value is 85,297 and the p value is 0,000. In chi- square table with CI of 95% and for 24 degrees of freedom the critical value is found as 36.41503. Statistical value of Q is greater than df and p smaller than the references value ($p<0.05$) so, the study population is in fact heterogeneous and we use Random Effects Model for the calculations. Table 8 shows the total effect size values of the studies according to the models.

Table 8

Total Effect Size Values of the Studies by Models (Students' Attitude)

Model	Effect size value Hedges's g	Standard error	Min. value	Max. value
Random Effects Model	0,584	0,103	0,382	0,785
Fixed Effects Model	0,500	0,054	0,394	0,605

We can see from this table that the overall effect size value is d= 0.584 in the Random Effects Model. This value stands for a medium effect. We can conclude that BBL has a positive and moderate effect on students' attitude.

Results Related to the Effect Sizes by Year of Study (Students' Attitude)

As a result of heterogeneity test the $Q_B$value is 1,889 and p value is 0,930. In chi- square table with CI of 95% and for 6 degree of freedom the critical value is calculated as 12,589. This result shows that the groups are homogeneous, thus we use Fixed Effects Model for calculating the effect size values. Results are summarised in Table 9. In other words, we can state that there is no significant difference in the effect sizes of the BBL on students' attitude in terms of the year of study.

Table 9

Effect Size Values by Year of Study (Students' attitude)

Study year	Number of studies	Effect size	Lower limit	Upper limit
2007	2	0,726	0,362	1,089
2008	5	0,478	0,237	0,718
2010	3	0,511	0,191	0,831
2012	3	0,225	-0,056	0,505
2013	4	0,774	0,500	1,049
2014	4	0,431	0,174	0,688
2015	2	0,429	0,021	0,837
Total	23	0,501	0,391	0,612

Table 9 indicates that the total effect size value is 0.501, the maximum effect size value belongs to year 2013 with 0.774 and the lowest effect size value is from year 2012 with 0.225.

Results Related to the Effect Sizes by Type of Study (Students' Attitude)

As a result of heterogeneity test the $Q_B$value is 0,056 and p value is 0,812. In chi- square table with CI of 95% and for 1 degree of freedom the critical value is calculated as 3,841. This result shows that the groups are homogeneous, thus we use Fixed Effects Model for calculating the effect size values shown in Table 10. We conclude that there is no significant difference in the effect sizes of the BBL on students' attitude in terms of the type of study.

Table 10

Effect Size Values by Type of Study (Students' Attitude)

Study Type	Number of studies	Effect size	Lower limit	Upper limit
PhD Thesis	9	0,438	0,277	0,599
Master Thesis	15	0,509	0,366	0,653
Total	24	0,478	0,370	0,585

We can see in the table that the total effect size value is 0,478, the largest effect size value belongs to the master's thesis type with 0,509 and the smallest effect size value belongs to the PhD thesis type with 0,438.

Discussion

In this meta-analysis 40 studies examining the effect of BBL on academic achievement are combined to attain effect sizes. The general effect size value d is calculated as 1,095 which means a large effect according to Cohen at al effect size classification. According to this result we can say that BBL has a positively and large effect on academic achievement. In other words, the students who were taught by BBL approach were much more successful than their pairs for whom the BBL was not the teaching method. In the literature, there are many studies resulting in BBL having a positive effect on academic achievement (Akyürek, 2012; Albayrak, 2012; Avcı, 2007; Aydın, 2008; Baş, 2010; Baştuğ, 2007; Bozbağ, 2015; Çakıroğlu, 2014; Canbulat, 2014; Çelebi, 2008; Çengelci, 2005; Ermurat, 2013; Esen, 2014; Eyüp, 2013; Görgün, 2010; Hasra, 2007; Hiçyılmaz, 2013; İnci, 2010; İnci, 2014; Özden, 2005; Palavan, 2012; Peder, 2009; Sadık, 2013; Süral, 2014; Tüfekçi, 2005; Usta, 2008; Yaman, 2014; Yıldırım, 2010; Yücel, 2011). In a meta-analysis on academic achievement, Gözüyeşil, (2012) found that the BBL had a positive but moderate effect on academic achievement, in our study we found a large effect. Unlike Gözüyeşil (2012), we only had Turkish studies. We suggest that the BBL can be used effectively in courses to increase students' academic success.

In this study we also looked into whether there were significant differences in the effect sizes of Brain Based Learning on academic achievement in terms of the year or the type of study and as a result there were no differences. However, if there was only one study in a year, we had to exclude that year. Similarly, for the study type, there was only a few number of articles after excluding duplicates with thesis type. Therefore, we should avoid making a conclusive decision instead, we should regard the result as a presentation of current situation. Gözüyeşil, (2012) examined and compared the effects of the BBL on academic achievement for periods of 6 years and she found that there was no significant difference among years.

Students' attitude is another research arm of this study. For this purpose, 25 studies which examine the effect of BBL on students' attitude were combined with meta-analysis. 22 studies found a positive effect and the general effect size value found is d=0,584. This result indicates that BBL had a positive and moderate effect on students' attitude. There are many studies in the literature showing BBL positively effects the students' attitude (Akyürek, 2012; Avcı, 2007; Baş, 2010; Çelebi, 2008; Ermurat, 2013; Eyüp, 2013; Hiçyılmaz, 2013; İnci, 2010; İnci, 2014; Kibaroğlu, 2015; Öner, 2008; Sadık, 2013; Tüfekçi, 2005; Yağlı, 2008; Yaman, 2014; Yücel, 2011). In courses where BBL methods are applied personal characteristics, movement, music, stress and threats are taken into account and that may have led to a better student attitude. However, at time of this study we did not find a meta-analysis study about this topic. According to our meta-analysis we can suggest that it is beneficial to use BBL in order to encourage students to take a better attitude towards courses.

Another research objective was to find out if there were significant differences in the effect sizes of BBL on students' attitude in terms of the year and the type of study. As a result, we did not find any significant differences.

As for the achievement analysis, we had to exclude single studies for each study type and year. Therefore, we could not state a conclusion.

The quality of a meta-analysis study depends highly on the quality of the studies included. We encountered some difficulties while literature search like some dissertations being not published, some papers being unreachable, some studies lacking required parameters so that the meta-analysis could be carried out with only a limited number of appropriate studies. Therefore, access to a larger number of papers containing necessary statistical data on the subject may better reveal the effectiveness of BBL on academic achievement and students' attitude. Limiting the study to a country has some advantages for accessing studies, corresponding, understanding the study language and circumstances and comparing with ease groups with similar cultural and educational background, besides study may be useful for national educational purposes. On the other hands including studies in other countries may be useful for discussing this topic on a broader and universal aspect. Another issue was the lack of meta-analysis studies on the effects of Brain Based Learning on academic achievement, we could only compare our study with Gözüyeşil's meta-analysis. Moreover, our meta-analysis is the only one on students' attitude. We compared effect sizes by study types and years, Gözüyeşil did compare by subject matters, education levels, sample sizes and country. We suggest the researchers who work on this topic to perform meta-analysis about persistence level, motivation and gender factors.

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