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THE IMPACT OF BIOLOGY TEACHING BASED UPON MULTIPLE INTELLIGENCE THEORY ON ACADEMIC ACHIEVEMENT: A META-ANALYSIS STUDY

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Abstract

The purpose of this research is to synthesize the results obtained from experimental studies on the academic achievement of students based on the multiple intelligence theory in biology and to reveal the effect of different characteristics in the studies by meta-analysis method. In this study, the magnitude of the impact of 14 studies on the academic achievement of students of biology education based on multiple intelligence theory was analyzed. As a result of the meta-analysis, it was determined that teaching based on multiple intelligence theory affects academic achievement in a positive direction compared to the traditional teaching method and the effect size value was 1.308. This value is quite high compared by Cohen's scale. In the meta-analysis study duration of application, sample size, publication type variables were analyzed. It is seen that the highest effect values are in the graduate thesis (d_{g-t}=1,549), 5-8 weeks ($d_{5\text{-}8\ weeks}$=2,007) and medium sample sizes (d_{medium}=1,427) $(51<n\leq75)$ according to the determined criteria.

Keywords: Multiple Intelligence Theory, Biology Teaching, Meta-Analysis, Academic Achievement

1.Introductıon

Multiple intelligence theory suggests that intelligence does not consist of a single dimension. Instead, it asserts that individuals possess various intellects on different levels. Thus, this enables educators to reveal the learning styles, interests, tendencies and skills of the individuals and prepare programs that emphasize the individual differences amongst the students and fortify these varieties (Vural, 2004).

According to Howard Gardner, human beings have nine different kinds of intelligence that reflect different ways of interacting with the world. Each person has a unique combination, or profile. Although we each have all eight intelligences, no two individuals have them in the same exact configuration. Dr. Howard Gardner, a psychologist and professor of neuroscience from Harvard University, developed the theory of Multiple Intelligences (MI) in 1983.

Gardner criticizes the traditional understanding of intelligence that advocates the belief that human intelligence can be measured objectively, and thus advances to the point that intelligence encompasses a multitude of capabilities that can not be explained by a single factor. Therefore, Gardner has called multiple intelligence theory and intelligence a broader

perspective on intelligence, and the individual talents, abilities and potentials of individuals in various ways (Saban, 2009).

Contrary to the traditional methods used nowadays, multiple intelligence theory increases the method richness by enabling the whole class to benefit from the education, by considering the multiple intelligence fields of the students (Kurt, Gümüş, & Temelli, 2013). Thus, this theory has gained quite a lot of importance in biology teaching.

With the multiple intelligence theory, the number of researches that analyze the academic achievements of the students have increased and it has also enabled the researches to reveal different conclusions on this matter. To make scientific progress, conclusions of different and independent researches that are realized on different or the same subject area have to be evaluated in a general or thorough manner.

In our country, there are researches in the literature that are realized independently on different occasions, which research the effects of the multiple intelligence theory based education on the academic achievements of the students. However, we are yet to see a study that brings together the conclusions of these researches as digital data and prove the effects of the multiple intelligence theory based biology education on the academic achievements of the students.

In the research, experimental research studies that prove the effects of the multiple intelligence theory based education on the academic achievement of the students are brought together and combined with the meta-analysis method. The primary ground of the research is to gather the findings obtained from individual researches with the meta-analysis method. Within this ground, the effects of the multiple intelligence theory on the academic achievement of the students have been revealed and the effects of the various study characteristics within the biology education with multiple intelligence theory have been designated. In this context, the primary objective of the research is to synthesize the results of the experimental studies that investigate the effects of the biology education with multiple intelligence theory on the students' academic achievements, compared to the traditional teaching practices, by using meta-analysis method. Thus, the following subject was investigated:

''Do the researches in which the multiple intelligence theory based biology education is used make any meaningful differences in the academic achievement of the students?''

- Do the researches in which the multiple intelligence theory based biology education is used make any meaningful differences in terms of the size of the influence based on the publication type?
- Do the researches in which the multiple intelligence theory based biology education is used make any meaningful differences in terms of the size of the influence based on implementation time?
- Do the researches in which the multiple intelligence theory based biology education is used make any meaningful differences in terms of the sample sizes?

2.Methods

2.1. Research Model

To discover whether the multiple intelligence theory based biology education makes any impact on the success of the students, meta-analysis method which is one of the literature surveying methods, was used in the research. Glass-meta analysis has stated that it is the statistical analysis of numerous analyses which arise from individual researches to integrate the findings (Glass, 1976). Meta analysis is the method of combining the conclusions of the

researches realized by different researches on different places and in different periods of times (Balcı, 2011). Meta analysis is the method of integrating the findings of different researches and reviewing the criticisms (Akgöz, Ercan, & Kan, 2004).

2.2. Collecting Data

The published and unpublished researches which were made between 1998 and 2016 accordance with the research problem were examined in the national databases. When these researches were investigated, 11 theses and 3 articles that are in accordance with the search criteria, were included in the research. Literature surveying process was concluded on 19 September 2016.

2.3. Inclusion Criterion

The criterions designated to determine the studies to be included in this research are as follows;

- The studies shall be experimental studies that utilize pre-test post-test control group model design,
- The studies shall also be studies that investigate the impact on the academic achievement of the students,
- The studies shall include the sample size of the experiment and control groups (n), arithmetic mean ($\bar{X}$) and standard deviation (SD) values or the data that can be used to calculate these values, which will enable the researcher to calculate the impact size,
- The studies must be realized within 1998-2016 years.

2.4. Data Coding

To compare the characteristics of the studies that are included in the research, the study characteristics must be coded. This coding system must be general that includes all researches and should also be unique to obtain the uniqueness of a study (Özdemirli, 2011).

The coding and encoder form used in this research is planned by the researcher. The created coding form consists of two parts. First part contains six questions and aims to obtain information about the characteristics of the study. In this part, information regarding the number of the study, name of the study, author or authors of the study, year of the study, sample count of the experiment and control groups were collected. The second part consists of questions that are created based on the study characteristics. In this part, study characteristics are designated as publication type, sample count and implementation period. The publication type is categorized as undergraduate thesis and doctoral thesis while the implementation period is categorized as 4 weeks or less, 5-8 weeks, 8 weeks or more. The sample size on the other hand is categorized as low ($n \leq 50$), medium ($51 < n \leq 75$) and high ($n > 75$).

To ensure the credibility of the research, it is important that the coding is realized separately by at least two researchers. The researches to be included in the meta analysis are coded by the researcher and another coder, by using a different encoding form. Encodings are calculated with the intraclass correlation analysis and the found result is 1.00. Encodings feature high credibility. The reason is that it consists of definite categories such as publication types of the categories, implementation time etc.

2.5. Data Analysis and Interpretation

The data obtained to combine the statistical data in various researches has to be converted to an impact quantity, which is a common measuring unit. Impact quantity is a standard measuring unit which is used in a research to designate the strength and direction of the relation (Öner Armağan, 2011). Today, we have statistical software such as Revman, MIX,

Metawin and Comprehensive Meta Analysis (CMA), which are developed for statistical analyses (Üstün & Eryılmaz, 2014). In this research, impact sizes and combined general impact size of each study were calculated by using Comprehensive Meta Analysis (CMA V2) program. CMA is a software that enables running many statistical analyses for realizing meta regression as well as the sub-group analysis and publication bias analysis (Üstün & Eryılmaz 2014). Thus, CMA program is opted for in this research. In this research, Hedges'd was used to calculate impact size. Besides, to calculate the average impact size in the CMA program, random effect model is chosen. In this research, .05 significance level was chosen for all statistical calculations.

Categorizations are used while interpretation impact sizes that are obtained as a result of the meta-analysis. Interpretation of the impact sizes of the researches to be included in this research was realized according to Cohen (1977). Cohen impact size values are interpreted as follows (Ergene, as cited in Cohen, 1999);

- Low if the impact size value is 0.20- 0.50,
- Average if the impact size value is 0.50- 0.80,
- And high if the impact size value is more than 0.80.

In meta analysis, before calculating the impact sizes, the statistical model to be used with the analysis (the tests which are used to measure the homogeneity of the impact sizes and population sample) is decided with Hedges and Olkin's (1985) Q statistics. There are two different models as fixed impacts and random impacts (Ayaz & Söylemez, 2015).

The most important premise of the fixed impact is the fact that there is only one real impact size for all works that are included in the meta analysis. In this sense, all differences observed on this premise arise from sampling errors (Üstün & Eryılmaz, 2014). In other words, if an impact of an initiative is the case, this doesn't interact with the study criterion and stays the same from research to research (Kınay, as cited in Akçil & Karaağaoğlu, 2012).

Random impacts model is used mostly when it is not appropriate to use fixed impact model. In random effects model, it is possible to include the both variance between the studies and the variance in the studies to the statistical analysis (Okursoy Günhan, 2009). According to this model, impact sizes may vary from research to research. It is expected that different impact sizes occur based on the features of the samples on which the studies are made (Kınay, 2012).

3.Results

3.1. Impact Size

Before obtaining the impact sizes, the model structure has to be decided as well. In other words, a heterogeneousness test shall be carried out before combining the studies. The Cohen test is implemented in the heterogeneousness test and the results are as stated in the Table 1.

Table 1. *Cohen test results for choosing between stable impact and random impact model*

Model	Impact Size and %95 Confidence Interval						Statistic and p-value		Heterogeneousness		
Model	Study numbers	Effect size	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Q value	df(Q)	P-value
Stable Impact	14	0.840	0.067	0.004	0.709	0.971	12.597	0.000	155.782	13	0.000
Random Impact	14	1.308	0.245	0.060	0.829	1.788	5.345	0.000			

As the table shows, the Q-value and the p-value that belongs to that is 155.782 and 0.000 respectively. The hypothesis that P value is 0.000 in 0.05 significance level against the

"model is in accordance with the random impacts model" alternative hypothesis. In other words, it is discovered that the studies create different impacts thus the model of the study is designated as the random impacts model.

Table 2. *The impact values of the multiple intelligence theory obtained within the random impacts model to the academic achievement*

Study No	Study Name	Hedge's g		%95 G.A.	
		Effect Size	Standard error	Lower limit	Upper limit
1	Kurt, Gümüş & Ermurat, 2011	1.808	0.264	1.291	2.325
2	Gürbüzoğlu, 2009	0.606	0.253	0.110	1.102
3	Kurt & Temelli, 2011	1.533	0.318	0.910	2.155
4	Kurt, Gümüş & Temelli, 2013	0.015	0.115	-0.211	0.241
5	Köksal, 2005	1.766	0.330	1.120	2.412
6	Şenci Ayaz, 2006	0.447	0.282	-0.106	0.999
7	Akman, 2007	0.965	0.301	0.376	1.554
8	Etli, 2007	0.912	0.245	0.431	1.392
9	Şalap, 2007	0.797	0.308	0.193	1.402
10	Kurt, 2009	1.677	0.258	1.171	2.183
11	Korkmaz, 2010	1.592	0.315	0.975	2.209
12	Elmacı, 2010	2.532	0.483	1.585	3.478
13	Kurtcuoğlu, 2007	3.700	0.423	2.871	4.529
14	Şakir, 2013	0.566	0.262	0.052	1.079
	Total Effect Size	**1.308**	**0.245**	**0.829**	**1.788**

As we can see in the Table 2, the impact size values based on the education with multiple intelligence theory could be interpreted according to Cohen's classification; 2 of the 14 studies included in the meta analysis had low impact size (14.28%), 3 of them had average impact size (21.43%) and 9 of them had a high impact size (64.28%). Thus, the impact size obtained from the random impacts model for all studies is 1.308, which suggests that the impact size of the studies is high.

The diagram which demonstrates the distribution of the impact size values which are created based on the random impacts model, is given at Figure 1.

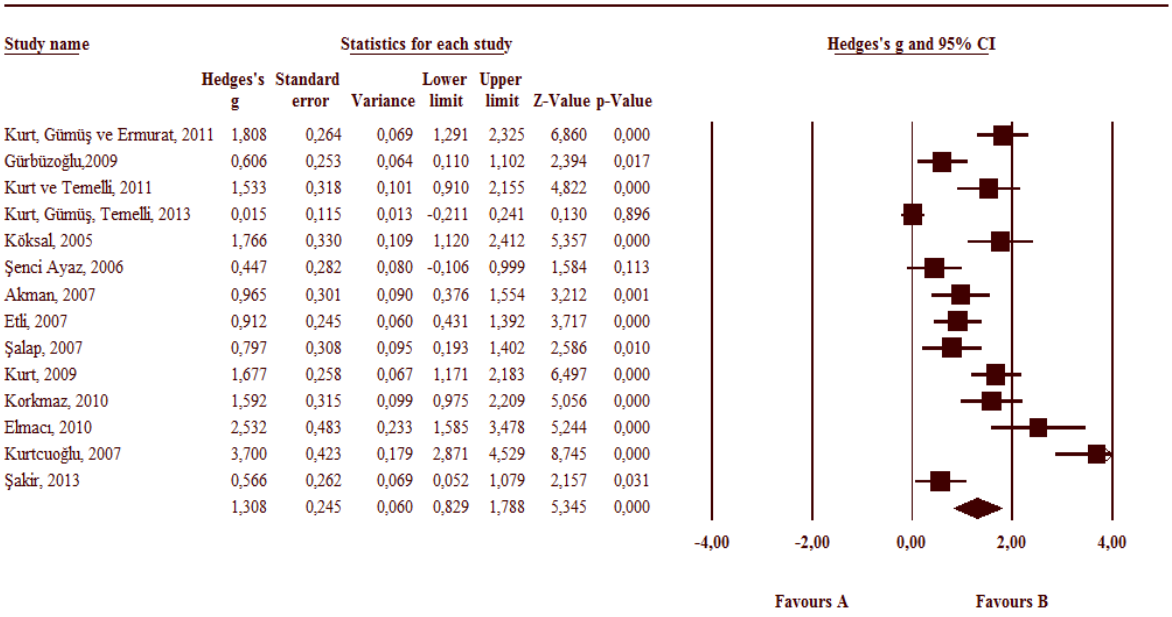

Figure 1. *Random effects of model – The graphic of forest showing the distribution of impact size values*

Looking at the Figure 1, it is possible to see that impact sizes vary between 0 and +4. We can say that impact sizes concentrate between 0-2. All studies have a positive sided impact. The general impact size of the 14 studies included in the meta analysis is designated as d=1.308 (95% confidence interval 0.829- 1.788). This impact size is quite high according to Cohen's interpretations. The students that are given education based on the multiple intelligence theory in biology field have obtained higher academic achievement compared to those who are educated with traditional teaching methods.

In the research, Rosenthal's secure N method is used, which is recommended to deal with the publication bias problem (Üstün & Eryılmaz as cited in Becker). As a result of this analysis, Rosenthal's secure N is designated as 873. This value is the study number that possesses zero impact level to reduce 1.308 general impact size. In other words, 873 studies with zero impact level are needed to reduce the 1.308 general impact size which is found as the result of the meta analysis. This result indicates that the publication bias in the meta analysis of this study is very low. Also Mullen, Bryant and Muellerle (2001) have stated that meta analysis results could be resolute only if the N/(5k+10) value exceeds 1 for the future studies (Üstün & Eryılmaz, as cited in Mullen, Muellerle, & Bryant, 2014). In this study, 873/(5.14+10) value is calculated as 10,91 which shows us that the meta analysis results are resolute.

Whether there is a publication bias or not could also be interpreted with the assistance of the Funnel Plot given at Figure 2

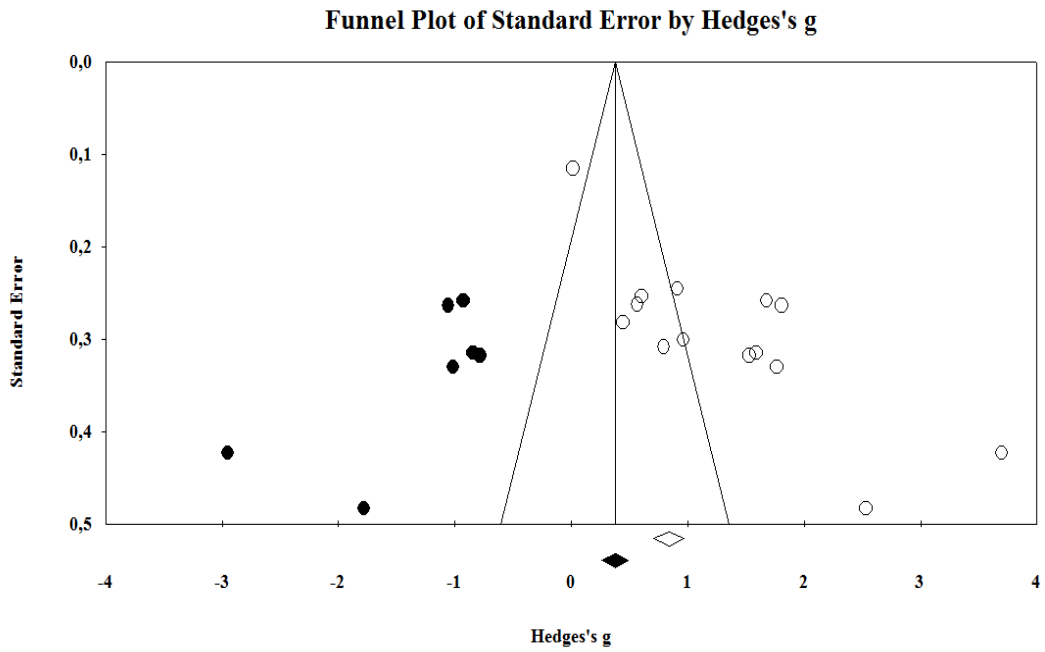

Figure 2. *Funnel Plot of the impact sizes*

If there is a publication bias in the funnel plot, the impact sizes will be distributed asymmetrically. If there is no publication bias, it will be distributed symmetrically. However, by adding seven studies to the left side of the funnel plot which is created with Duval and Tweedie's Cut and Insert method, we can see that a symmetry could be achieved. This also indicates that publication bias is low.

- Related to the Publication Types of the Studies

In terms of academic success; the findings regarding to whether the impact sizes differ based on the publication type are given in Table 3.

Table 3. *Analysis results*

Groups	Impact Size and %95 Confidence Interval					Statistic and p-value		Heterogeneousness		
	Study numbers	Effect size	Standard error	Lower limit	Upper limit	Z- value	P-value	Q-value	df	P-value
PhD thesis	2	0.586	0.182	0.230	0.943	3.220	0.001			
Article	3	1.099	0.666	-0.206	2.405	1.650	0. 099			
Post Graduate thesis	9	1.549	0.283	0.994	2.104	5.469	0.000	8.281	2	0.016
Total	14	0.880	0.149	0.587	1.172	5.892	0.000			

We determined to Average effect size for dissertation 0.586, for this article 1.099 and for high license thesis 1.549. We refused that average effect of dissertation size equal to 0.05 Effect size of dissertation is statistically significant. The p value of statistic of the argument article's effect size is equal to 0 is 0.099 and we did not refuse that by 0.05 level but we said statistical article's average effect was different 0 by 0.10 significance level. P value of the static of Post Graduate thesis's average effect size is 0.000 and that was not sense by 0.05 level. Post Graduate thesis's average effect size was statistically sense. P value that the static

of three group's effect size was same or not 0.016 and that was not sense by 0.05 level 1 mean, that was not the same of dissertation article, high license thesis's average effect size. All of the groups' effect size was positive but effect size was not same. The highest effect was in post graduate thesis ($d_{Post\ Graduate}$ =1.549) and the lowest effect was in dissertation ($d_{PhD\ thesis}$=0.586) in three groups.

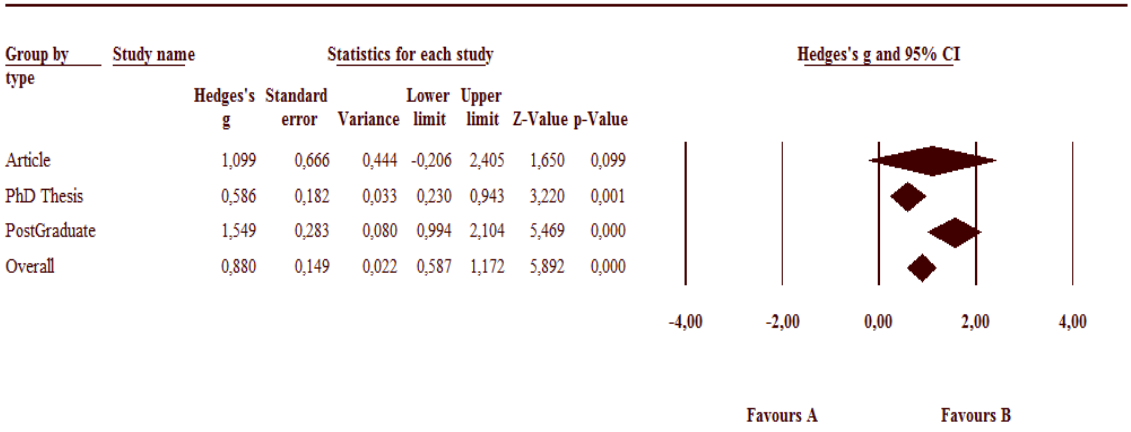

Figure 3. *Random effects model – The graphic of forest showing the distribution of the effect size values of the works according to the publication type*

Figure 3 was about effect size by broadcasting type. We determined that effect size was between that 0-2. That was not the difference that average effect size of dissertation, article and Post Graduate thesis.

-Related to the According to the duration of the application of the Studies

For academic success, Table 4 showed that effect size changed by application time or not.

Table 4. *Impact size differences according to application periods of studies under random effects model results of analysis*

Groups	Impact Size and %95 Confidence Interval					Statistic and p-value		Heterogeneousness		
	Study numbers	Effect size	Standard error	Lower limit	Upper limit	Z- value	P-value	Q-value	df	P-value
4 weeks or less	5	0.743	0.123	0.502	0.983	6.051	0.000			
5-8 weeks	5	2.007	0.332	1.355	2.658	6.038	0.000			
8 weeks or more	4	1.173	0.541	0.112	2.234	2.166	0.030	12.988	2	0.002
Total	14	0.906	0.113	0.686	1.127	8.048	0.000			

At the time of administration, the mean effect size for 4 weeks or less was 0.743, the mean effect size for 5-8 weeks was 2.007, and the mean effect size for 8 weeks or more was 1.173. The p-value of the obtained statistic for claiming that the mean effect size is equal to zero for 4 weeks or less is rejected at a significance level of 0.05, which is 0.000. In other words, the average effect size of application periods of 4 weeks or less is statistically significant. The p-value of the obtained statistic for claiming that the mean effect magnitude is equal to zero for 5-8 weeks is rejected at a level of significance of 0.05. In other words, the mean effect size of 5-8 weeks of application time is statistically significant. The p-value of the obtained statistic for claiming that the mean effect size is equal to zero for 8 weeks or more is 0.030 and the

claim is rejected at a significance level of 0.05. In other words, the mean effect size of 8-week and more application periods is statistically significant. The p-value of the statistic obtained from testing for the same effect sizes of these three groups is 0.002, which is rejected at a significance level of 0.05. That is, the mean effects of application periods of 4 weeks and less, 5-8 weeks and 8 weeks and more are not the same. The effect sizes of all working groups are positive but the effect sizes are not equal. It was determined that the greatest effect among the three groups was the duration of application ($d_{5\text{-}8\ weeks}$ = 2.007) for 5-8 weeks, and the application time ($d_{4\ weeks\ and\ less}$ = 0.743) for 4 weeks and less.

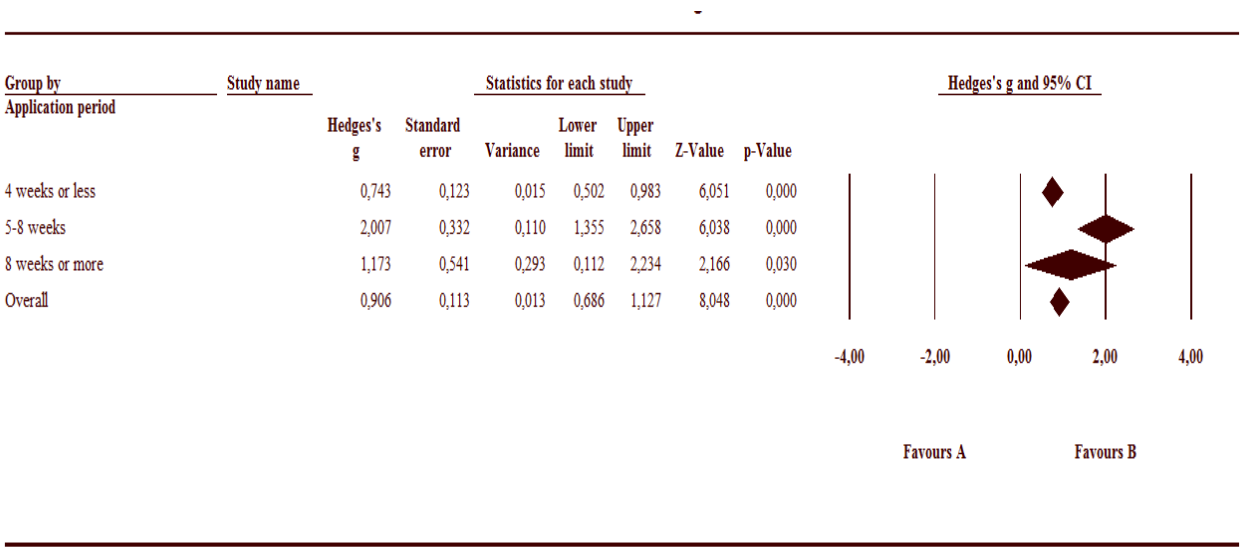

Figure 4. *Random effects model – The graphic of forest showing the distribution of impact magnitudes of the works according to application period*

In Figure 4, the effect sizes are given according to the application times of the works. The effect sizes in the three groups are generally between 0 and 2. It was found that there was no significant difference between the mean effect sizes of all application periods in the positive direction, 4 weeks and less, 5-8 weeks and 8 weeks and more application periods.

- Related to the size of Sample

In terms of academic success and whether the effect sizes differ according to the sample sizes are given in Table 5.

Table 5. *Impact size differences according to sample sizes of studies under random affine models the result of the analysis*

Groups	Impact Size and %95 Confidence Interval					Statistic and p-value		Heterogeneousness		
	Study numbers	Effect size	Standard error	Lower limit	Upper limit	Z- value	P-value	Q-value	df	P-value
Low (n≤50)	6	1.281	0.274	0.743	1.819	4.667	0.000			
Medium (51<n ≤75)	5	1.427	0.450	0.545	2.309	3.170	0.002			
High (n>75)	3	1.151	0.675	-0.172	2.474	1.706	0.088	0.133	2	0.936
Total	14	1.302	0.221	0.868	1.736	5.882	0.000			

The p-value of the obtained statistic for claiming that the mean effect size of the sample sizes at the low sample size is equal to zero is 0.000 and the claim is rejected at the significance level of 0.05. In other words, the mean effect size of sample sizes at low level is

statistically significant. The p-value of the obtained statistic for claiming that the average effect size of the sample sizes at the middle level is equal to zero is 0.002, and the claim is rejected at the significance level of 0.05. In other words, the mean effect size of sample sizes at intermediate level is statistically significant. The p-value of the obtained statistic for the assertion that the mean effect size of the sample sizes at the large level is equal to zero is 0.088 and it can be said that although the claim cannot be rejected at the significance level of 0.05, the mean effect size of the large sample sizes is statistically different from zero at the significance level of 0.10. The p-value of the statistic obtained from testing for the effect sizes of these three groups is 0.936, which is rejected at a significance level of 0.10, although the claim cannot be rejected at the level of 0.05 significance. That is, the sample sizes at the low level, the sample sizes at the middle level and the sample sizes at the large level are not the same. The effect sizes of all the study groups are in the positive direction but the effect sizes are not equal. It was determined that the largest effect among the three groups was the moderate sample size (d_{medium} = 1.427) and the smallest sample size was the large sample size (d_{high} = 1.151).

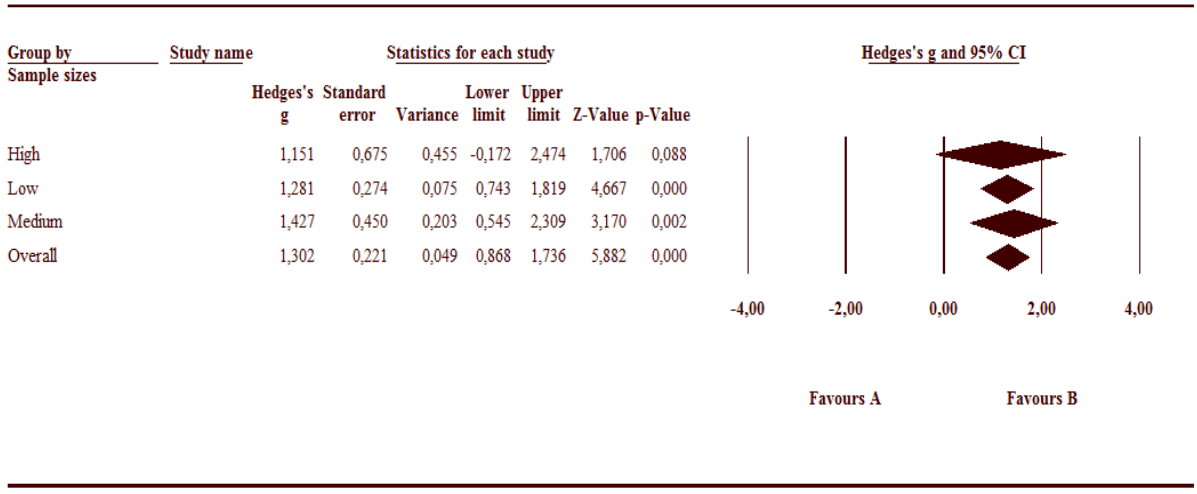

Figure 5. *Random Effects Model – The graphic of forest showing the distribution of impact size values of the runs by their sample sizes*

In Figure 5, the effect sizes are given according to the sample sizes of the studies. The effect sizes in the three groups are generally between 0 and 2. It has been found that there is no significant difference between the mean effect sizes of the sample sizes at the low, medium and large levels.

4. Discussion

Usual influence quantity of the studies that have been included to meta-analysis is calculated as d=1.308. It is a very big influence quantity considering Cohen scale. In other words, the students who have been educated according to multi-intelligence theory show more success than the students who have been educated according to traditional methods. According to the results of the studies that include the teaching of multi-intelligence theory in biology subjects, the students who have been educated according to multi-intelligence theory show more success than the students who have been educated according to traditional methods (Akman, 2007; Elmacı, 2010; Etli, 2007; Korkmaz, 2010; Köksal, 2005; Kurt, 2009; Kurtcuoğlu, 2007; Şalap, 2007; Gürbüzoğlu, 2009). Result of this meta-analysis study is very consistent comparing to the literature researches. In other words, the teaching of multi-intelligence theory in biology subjects increases the academic success of the students.

This meta-analysis includes study 3 articles, 9 post graduate theses and 2 PhD theses. Comparing the results of these three groups, the influence quantities are positive but there is no significant influence difference in between. The highest influence quantity is post graduate thesis (d_{PG}=1.549), the lowest influence quantity is doctoral thesis ($d_{PhD\ thesis}$=0.586). Using at least 5 different data in the Hedge's d used for effect size calculation gives healthy results (Rosenberg, Adams, & Gurevitch, 2000). For this reason, more experimental work is needed in this area in Turkey in order to make definite generalizations.

Meta-analysis results show that 4 week or less time period has got average, the period of 5-8 weeks and more than 8 weeks has got high influence quantity. There is not any significant difference among these groups. Considering this result, influence quantities are similar to each other. Increase in the time has got positive effects in multi-intelligence theory.

The studies that are going to be included to meta-analysis have been sorted as low ($n \leq 50$), medium ($51 < n \leq 75$) and high ($n > 75$); and analyzed. Comparing the apply group quantity, the highest influence quantity is average ($51 < n \leq 75$) in the studies that shows apply quantity (d_{medium}=1.427), the lowest influence quantity is the high($n > 75$) in the studies that shows result of (d_{high}=1.151). However, there is not any significant difference in studies regarding to apply quantity.

Below suggestions are defined according to the findings of the research for the researchers:

Research studies confirm that Multiple Intelligence Theory can be helpful in education. It has been found that biology teaching based on multiple intelligence theory has a high positive effect on the academic achievement of students according to traditional teaching methods. Biology teachers can use multiple intelligence theory for effective and more permanent learning.

- At the sample size, there was no significant difference in the magnitude of impacts on academic achievement of students in biology teaching based on multiple intelligence theory. For this reason, multiple intelligence theory can be applied in different sample sizes. However, since the sample size at the intermediate level ($51 < n \leq 75$) is more effective in this study, researchers in this area should consider this sample size when implementing it.

- According to the duration of the application of studies, there was no significant difference in the effect sizes of the multiple intelligence theory on the academic achievement of the students. For this reason, researches in this area based on multiple intelligence theory can be done during different application periods. However, since it is determined that the duration of the study is more effective between 5 and 8 weeks in this study, it can be suggested that the researches in this area should not be constructed without taking into consideration this duration of the study in the future researches.

- According to the publication type, when the effect sizes are examined, it is determined that the master thesis has a high level of influence compared to the article and doctoral thesis. However, it should be possible to increase the availability of these works converted from the thesis format to the article.

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ENDNOTES

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