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Meta analysis of the computer aided studies in mathematics: A sample of Turkey

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Abstract

The Scientific and technological improvements that occur as a result of the race for the improvement of life standards between countries helps the education inevitably. The expectation of stableness of this occurrence of scientific and technological change on educational environment causes the use of different methods and techniques in education. Just like developed countries, there is a dramatic increase in use of Computer Aided Education Methods in our country. Computer Aided Education Method is often being used to measure difference in success in academic researches that establishes surveys and works on various experiment groups. Meta- analysis summarizes various studies on different fields and enables to achieve a common conclusion by combining the results. Therefore, Meta-Analysis is a method of combining the results of different studies. Aim of this research is to achieve an opinion about the use of Computer Aided Education Method in our Country by using Meta-Analysis. In this research, Meta-Analytic method that enables to calculate common effect sizes and to combine the results of similar studies was used. In this study, the most important result achieved by the meta-analysis is that the Computer Aided Education Method has a significant advantage as a method of teaching.

*Keywords***:** Computer aided education method; Mathematics; Meta-analysis
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1. Introduction

The race for the improvement of life standards between countries that already exists for a long time is evolving rapidly to a race for the improvement of education standards that is being given to individuals that establishes the society. Educational level of each individual within the society is the basic indicator of that country's development level. Therefore all countries are trying to increase their investments and improve their educational level in all areas. Proliferation of investments in education is accelerating the quality of education and carrying personal development the upper levels.

To improve the educational level of communities can only made by increasing the quality of education that provided in schools. To improve the quality of schools, the physical improvement of classrooms and laboratories must increase in an appropriate proportion with the country's economic situation. It is understood that the improvement of the individuals is proportional to the improvement of educational level of individuals. To make improvement for conditions of educational environment contribute to improvement the quality of education, the tools that used in these environments, computer equipment and other materials also have to be renewed. But this must not be understood as physical improvement of conditions of educational environment is enough to improve educational level. So, the learning and teaching techniques that are being used in the educational environment must also be seen as an important factor. The contribution that being made to academic success by teaching methods and techniques is growing rapidly. Therefore, learning and teaching techniques is an important factor. Not only in educational environment, teaching methods and techniques also an important factor in educational programs that affects these environments directly. This technological hardware that is being used in an educational environment and the techniques and methods that affects the usage of them are the most important factors that affect individuals' educational level.

The most important factors of improvement of the educational level of individuals as the main indicator of social development, are learning techniques and methods. These important factors are parts of both educational environment and the factors that affect these environments directly.

Because of the direct affection between technology and education as values that increases parallel to development of countries, learning methods and techniques has plenty of usage areas. In educational environment all learning techniques and methods that are found appropriate are being used frequently. One of the methods that are being used in educational environment is computer aided teaching method [1-4].

As an indicator of social development, improvement of the educational level of the individual is considered as indispensable investment area. Like the other countries, computer aided education method is the most preferred technique in our country as well. This computer-assisted teaching method is known as an effective method in concept teaching. In learning environments, computer-aided teaching method commonly used for correction of misconceptions but in some studies it is also preferred for academic success and behavior surveys [5-10]. How computer-assisted teaching method that preferred a lot in our country effects academic success has been analyzed.

Computer-assisted teaching method that has been analyzed by the means of effects to academic success is being used with quite a number of learning method with great harmony. With that harmony in mind, this computer aided education method is often used in academic success for analysis studies that establishes control and experiment groups [5-10].

Meta-Analysis in literature studies can be described as analysis of analysis in a way. Meta-Analysis is an analysis of analysis method that combines outcomes of many independent studies that are about a particular subject and analyzes the statistical findings of these studies. Meta-Analysis, summarizes different studies in scientific areas and enables to reach a common judicial by combining the results [5-15]. Therefore meta-analysis is the method of combining the results of different studies. Similarly, in education, meta-analysis analyzes the analyses of various studies that made in the same area giving statistical results. So the meta analysis combines the results of the studies that gives quantitative results and analyzes the statistical outcomes that has been reached with these studies. In education a variety of experimental research is being conducted that can be meta-analyzed. In teaching areas, mostly in researches in measuring academic success, meaningful differences between groups can be found.

Like in every part of the world, studies that aim to find a meaningful difference between traditional education and computer aided education are being conducted in our country too. The studies that using computer aided educational system in experiment groups that being done in our country seem to be meta-analyzable.

1. 1. Problem of the Study

When the experimental studies that measures effectiveness' of computer aided education applications that is being used in mathematics areas comparing to other areas that has been conducted between 2006-2009 in our country summarized, "is there any statistical meaningful difference comparing to other methods?" question constitutes the problem of the research.

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1. 2. The purpose of study

The purpose of this study is to obtain an opinion about effectiveness of computer aided education method in different lessons that is being conducted in various branches using meta-analysis. When all experimental researches that are comparing the success of computer aided education methods put together, the level of the meaningful difference between traditional education and computer aided education are being conducted in our country will also be studied.

1. 3. Importance of Study

This study is important in terms of describing the reason of researches that being done with computer aided education methods in our country. Meta-analyzing these researches is also important because its benefit of being an example to other literature studies and being an analysis of analysis's.

1. 4. Limitations of the Study

In general, this study is limited by the characteristics of meta-analysis as a literature research method. Mathematics studies that have been conducted experimentally, using computer aided education methods between the years 2006 and 2009, builds the limits of this study.

2. Method

Various mathematical studies that are being conducted using computer aided educational method have been selected and analyzed. In order to determine the average effectiveness of computer aided educational method in terms of academic success, this studies has been examined and meta-analyzed. Briefly, in this research, meta-analytic scan that enables combining the results of similar studies and measure size of the common effect has been used [16-19].

2. 1. Data Collection

First of all, when which studies can be related to this research is considered, it can be seen that the most important search criteria are "computer aided", "computer based", "web aided" and "web based." Therefore from studies conducted in areas of mathematics, the ones with computer aided education content have been collected in order to use in research. In these studies generally computer aided education, activities that are prepared to correct the misconceptions in the fields of mathematics, and the concept works for teaching, for academic achievement and behavior surveys can be seen in the form of various presentations. With the content of computer assisted instruction in teaching mathematics, 95 studies that are comparative studies between experimental and control groups were included. All of these aspects of the work in mathematics, students' academic achievements have also been analyzed in terms of whether or not being contributed by computer-assisted instruction.

2. 2. Order of operations

Studies on experimental or quasi-experimental ones, in terms of computer-assisted instruction have been selected regarding they are comparing students' academic success or not. For the reason that they give Average value and standard deviation values, the findings of a total of 18 studies included in the study. These 18 studies that included in this study are, 8 master theses, 2 PhD theses, 4 scientific papers and 4 other scientific papers that have been published in refereed journals. In addition, 2 each of 7 studies, in a paper 3, in a study, 7, in a paper 9, 1 each of eight different study's findings of average values and standard deviations are given. Thus, a total of 19 studies evaluated and 30 different findings were reached.

2. 3. Coding process

The number of students, average of experimental group, standard deviation of the test group, average of control group, standard deviation of the control group, t values and p values of 30 assessable studies has been coded. In addition, the coding of these studies have been included author names and publication dates. The encoding process was conducted for studies related to the findings of this preliminary test.

2. 4. Reliability and validity

It has been detected that in all the studies that have been included in this research, a review of reliability and validity is done. Therefore, for all the coding of this study has been identified as reliable and valid.

2. 5. Data analysis

To compute the differences between the averages of the experiments and control groups, Mean Difference Effect Meta-Analysis must be used.

Table 1. Effect Size Formulae and Conversion Table

Statistics	Effect size (MD) formulas of conversion	Explanation
Mean Values	$MD = Me - Mc$	M_e=Mean of the experiment group M_c=Mean of the control group
Variances	$Sp^2 = \frac{(Ne-1)Se^2 + (Nc-1)Sc^2}{(Ne+Nc-2)}$	Ne=Number of subjects in the Exp. Group Nc= Number of subjects in the Ctrl Group S_e^2= Variance of the Experiment Group S_c^2= Variance of the Control Group

In Table 1, the conversion formulae for the Effect Size (MD) have been provided. In order to do the Meta-Analysis of the data that has been saved in relative studies, package program MIX-Version 1.7 (Meta-Analysis Made Easy) has been used.

3. Findings and discussions

30 dataset of 19 experimental studies that conducted in accordance with the criteria specified in our country, assessing the efficiency of using computer-assisted instruction, have been combined with the Meta-Analysis method. For 30 dataset of 19 experimental studies numerical and graphical findings have been listed.

Table 2. Meta-Analysis Findings that has been computed with MIX package program.

Heterogeneity	df	Mean Effect Size (Meta-Analysis Outcome)	99% CI
Q total 259,8178	29	E++ 3,9867	3,2852 to 4,6881

Findings of Heterogeneity Test can be seen at Table 2. According to these findings, it can be understood that the studies are homogeneous in 0:01 critical importance level and that they can be combined. Mean Effect Size is E++ = 3,9867. So computer aided instruction seen as more successful than traditional teaching with a value of +3,9867.

3. 1. Normal Quantile Plot

Graphic looks like normal distribution when distribution of the data aline on X=Y. In the graphic shown in Image-1, it can be seen that the data distribution

alines on X=Y. So it can be understood that the graphic looks like normal distribution. Graphic of the effect size of data set look like normal distribution. So this makes us think the data is suitable for computing the total effect size.

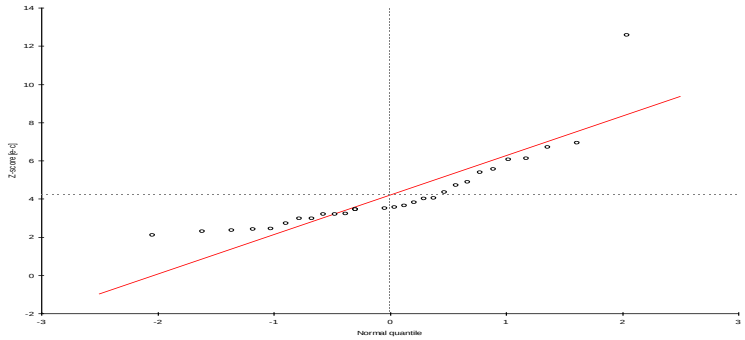


Image 1. Normal Quantile Plot.

3. 2. Effects sizes and exclusion sensitivity plot

Graphic of Effect Size and Exclusion Plot can be seen at Image 2. The person concerned doesn't show any fluctuation and doesn't show any heterogeneity symptom either. So it can be seen that the Mean Difference Effect Size data set is a research design that has a homogeneous distribution. According to graphic, it can also be seen that all the MD values are positive and as a whole they are internally consistent.

Mean difference levels, standard deviation levels and the p values of Meta-Analysis that has been made for given studies have been shown in Table 3. According to this, only five data set has a *p* value higher than 0.01 (Table 3). Various data findings in relative studies have been listed and in *t* values among these it has been seen that there is no meaningful difference between experiment and control groups. It can be seen from Table 3 that in all of other studies there is a meaningful difference between experiment and control groups in favor of the control groups. So it appears that the data sets that have been obtained from

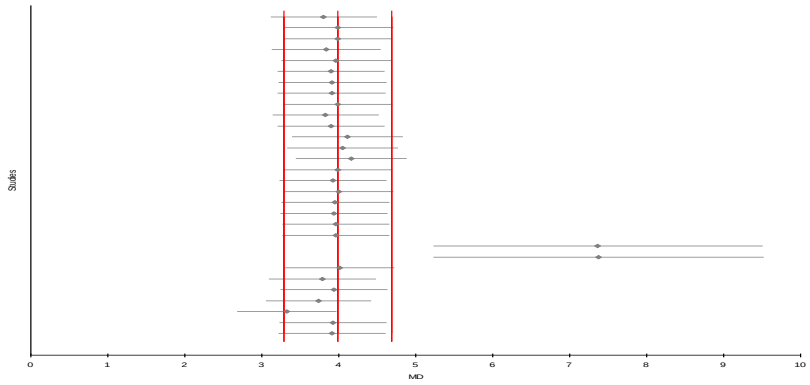


Image 2. Effect sizes and exclusion sensitivity plot.

relative studies can be combined and a common effect size can be given. If statistical test for heterogeneity shows a low *p* value, it must be known that the differences between findings are beyond negligible. For this reason, if *p* value is not very high, possible heterogeneity must also be visually analyzed. For example, if the results of heterogeneity will be found at $p = 0.0001$ meaning level, it must be interpreted as the study findings are homogeneous. Thus, it could be argued that the fixed effects model and the findings of different studies have a common effect. So it can be said that these 30 dataset have a common effect in the terms of computer aided instruction.

p value, *Q* value, *E*++ (Meta-analysis outcome) value and the other findings of this meta-analysis have been shown in Table 4. *Q* and *E*++ values have been given and interpreted in Table 2. As seen from here, in meta-analyses that have been made for 30 datasets, the critical importance level of $p < 0.0001$ has been achieved.

This critical importance level value shows that the comparative studies that measure the difference between computers aided instruction and traditional instruction is supported. *p* value that has been acquired is a sign that makes us think that these studies can be combined, supported and elected.

The number of subjects, mean values and standard deviation findings, fields of study and numbers of 30 datasets that has been used in this meta-analysis study have been listed in Table 5. Accordingly, 19 mathematical studies that have been conducted in our country have been included in this meta- analytical search.

In addition, Table 5, the experimental group and control group, the number of subjects, the mean and standard deviation values, respectively, instead of e, c, N, M, SD abbreviations used.

4. Results

The effect size E + + = 3.9867 and critical level of $p < 0.0001$ values that has been acquired from the meta-analysis of 19 studies of a total of 30 data set, shows us that the computer aided instruction is academically on a large scale more effective than traditional instruction. All the studies that established the relative dataset have united in this conclusion [37-40].

Meta-analysis of this normal distributional graph shows us that the relative dataset is sufficient and suitable for effect size computation. In the other hand, effect sizes and rejection sensitivity graphs shows that these 30 datasets doesn't show any ripple, deviation and heterogeneity. So, it has been concluded that relative dataset has a homogenous search pattern.

The *p* value that has been acquired from the meta-analysis of the related study shows us that the related computer aided instruction studies can be united, supported and preferred. There is a growing interest on computer aided instruction in our country. Our education institutions are being enhanced by MEB in the terms of equipment, tools, availability of teaching methods and techniques [41-45]. It can be predicted that literature will gain a lot of study with growing interest and developing richness of hardware.

The most important result that has been reached with meta- analytical scan that has been conducted in this research is the prominent superiority of the computer aided instruction. The superiority that has been achieved in favor of computer aided instruction, as a result of the studies that have been conducted in Turkey, shows us that the studies of computer aided instruction are important enough to encourage.

Table 3. Meta-analysis MD, 99% CI and *p* value findings

Study ID	Date	Reference	MD	99% CI	*p*
Study 1	2006	[20]	15	8,6102 to 21,3898	< 0,0001
Study 2	2006	[21]	3,525	1,0362 to 6,0138	0,0003
Study 3	2007	[22]	3,696	0,9325 to 6,4595	0,0006
Study 4	2007	[23]	5,02	3,088 to 6,952	< 0,0001
Study 5	2007	[23]	3,73	1,7656 to 5,6944	< 0,0001
Study 6	2007	[24]	20,54	8,3349 to 32,7451	< 0,0001
Study 7	2007	[1]	10,29	2,5955 to 17,9845	0,0006
Study 8	2007	[25]	6,67	2,1712 to 11,1688	0,0001
Study 9	2007	[22]	3,696	0,9325 to 6,4595	0,0006
Study 10	2007	[26]	14,22	7,608 to 20,832	< 0,0001
Study 11	2008	[27]	6,65	2,4068 to 10,8932	< 0,0001
Study 12	2008	[27]	2,2	0,4397 to 3,9603	0,0013
Study 13	2008	[27]	2,85	1,2894 to 4,4106	< 0,0001
Study 14	2008	[27]	1,6	-0,1167 to 3,3167	0,0164
Study 15	2008	[27]	3,68	0,7133 to 6,6467	0,0014
Study 16	2008	[28]	12,29	2,3753 to 22,2047	0,0014
Study 17	2008	[29]	3,23	-0,2034 to 6,6634	0,0154
Study 18	2008	[30]	7,8	-0,7636 to 16,3636	0,019
Study 19	2008	[30]	9,74	1,3133 to 18,1667	0,0029
Study 20	2008	[31]	12,23	-1,5335 to 25,9935	0,0221
Study 21	2008	[31]	11,74	-2,6717 to 26,1517	0,0359
Study 22	2009	[32]	0,14	0,0731 to 0,2069	< 0,0001
Study 23	2009	[32]	0,16	0,0571 to 0,2629	< 0,0001
Study 24	2009	[33]	3,18	0,1674 to 6,1926	0,0065
Study 25	2009	[34]	11,4	6,5959 to 16,2041	< 0,0001
Study 26	2009	[34]	7,66	1,0005 to 14,3195	0,003
Study 27	2009	[35]	12,13	7,6144 to 16,6456	< 0,0001
Study 28	2009	[35]	21,4	17,0152 to 25,7848	< 0,0001
Study 29	2009	[36]	17,41	4,651 to 30,169	0,0004
Study 30	2009	[36]	12,6	3,4623 to 21,7377	0,0004

Table 4. Evidence dissemination (meta-analysis)

Meta-analysis		Evidence dissemination bias	
General		**General**	
Number of studies	30	Current outcome measure	MD
Number of participants	2381	Current weighting method	IV
MD (IV) Random effect model		Current model	Random effect
Meta-analysis outcome	3,9867	Original meta-analysis outcome	3,9867
99% CI lower limit	3,2852	99% CI lower limit	3,2852
99% CI upper limit	4,6861	99% CI upper limit	4,6861
z	14,6401	**Effect assessment**	
p-value (two-tailed)	< 0,0001	Rank correlation tau-b (continuity corrected)	0,4808
Heterogeneity		Ties	-1,523588754
Q	259,8178	P-Q (se)	208 (56,0506)
p-value (two-tailed)	< 0,0001	Z	3,7371
		p-value (two-tailed)	0,0002
		Regression method	Egger
		Regressor weighting	None
		Intercept	4,137
Meta-analysis		Evidence dissemination bias	
		99% CI lower limit	3,0183
		99% CI upper limit	5,2557
		p-value (two-tailed)	< 0,0001
		Sensitivity analysis	
		Fail-safe N	2361
		Tolerance level	160
		Trim-and-fill method (automatic)	L0
		Number of imputed studies	14
		Resulting meta-analysis outcome	2,5391
		99% CI lower limit	1,8206
		99% CI upper limit	3,2576

Table 5. Number of subjects of the studies, the findings of mean and standard deviation

Subjest area	Dates	Study	N(e)	M(e)	SD(e)	N(c)	M(c)	SD(c)
Study 1	2006	[20]	31	8,240	1,550	29	6,410	2,190
Study 2	2006	[21]	31	8,520	2,200	29	7,150	2,430
Study 3	2007	[22]	31	9,070	2,170	29	4,860	2,080
Study 4	2007	[23]	22	70,900	7,960	20	63,250	7,650
Study 5	2007	[23]	22	70,450	25,630	20	49,000	9,400
Study 6	2007	[24]	35	76,450	12,590	35	65,710	7,470
Study 7	2007	[1]	25	64,160	11,100	25	56,680	11,150
Study 8	2007	[25]	40	48,580	12,400	40	44,230	12,950
Study 9	2007	[22]	40	42,310	17,080	40	25,120	16,600
Study 10	2007	[26]	25	41,120	17,239	25	27,720	9,603
Study 11	2008	[27]	22	78,730	14,870	22	58,770	12,430
Study 12	2008	[27]	46	28,630	4,804	46	18,869	6,130
Study 13	2008	[27]	25	64,16	11,0	25	56,68	11,15
Study 14	2008	[27]	22	57,000	12,539	21	47,140	15,252
Study 15	2008	[27]	30	12,161	2,018	31	10,000	2,804
Study 16	2008	[28]	66	18,000	6,580	62	15,200	5,340
Study 17	2008	[29]	26	70,810	18,370	27	59,690	15,680
Study 18	2008	[30]	8	30,120	4,010	8	19,120	8,770
Study 19	2008	[30]	29	168,413	16,796	29	148,862	13,806
Study 20	2008	[31]	37	70,810	20,490	37	50,270	20,270
Study 21	2008	[31]	22	17,590	3,187	19	13,894	3,619
Study 22	2009	[32]	36	63,660	11,000	36	49,440	10,780
Study 23	2009	[32]	24	16,040	1,940	24	13,330	2,920
Study 24	2009	[33]	29	10,200	1,650	29	8,340	2,170
Study 25	2009	[34]	29	22,4	7,3	29	14,4	9,4
Study 26	2009	[34]	22	53,000	11,180	21	40,710	13,850
Study 27	2009	[35]	35	10,427	2,726	35	6,543	2,582
Study 28	2009	[35]	42	18,476	4,049	43	9,884	2,880
Study 29	2009	[36]	40	91,583	10,170	40	77,792	12,929
Study 30	2009	[36]	114	15,19	4,29	139	10,45	3,84

5. Conclusions and suggestions

This meta-analysis study has been concluded that computer assisted instruction was more successful in academic terms. But it is not suitable to give an advice because of its lack of quantitative studies inside its literature environment. Moreover it is unthinkable to accept the last test results as sole indicator of educational quality. Thus, it is thought to be useful to support this meta-analysis with the studies that include quantitative researches.

Moreover, as a literature scan method that can analyze, unite or compare related individual studies and can enable to reach concrete datasets meta-analytical scan is thought to be a useful opportunity for science.

Based on this result, with the assumption of similar studies will also be useful, computer aided instruction can be advised to all educational institutes, in the condition of sufficient equipment.

It is considerable for the institutions that plan the education and develop the curriculum, to include material that is suitable for type and context of courses. It can be argued that it will raise the quality of education to higher levels.

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