

The Meta-Analysis of the Effect of Computer Aided Instruction on Student Attitudes in Science and Mathematics

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Abstract: In the research the effect of computer aided instruction on student attitudes towards the lesson in the fields of physics, chemistry, biology and mathematics has been searched. In this research, studies which were made between 2002 – 2011 years in physics, chemistry, biology and mathematics education, and which include the comparison the effect of computer aided instruction on student attitudes with traditional methods, have been merged together. Fifty-six appropriate studies for criteria were chosen and combined with the meta-analysis method for 142 Master of Science and PhD thesis, and 45 articles. At the conclusion of the research, it data supply review that, computer aided instruction has a more effective influence in a positive way on the attitude of the students towards lesson in comparison with the traditional method in the fields of physics, chemistry, biology and mathematics education.

Keywords: Science Education, Mathematics Education, Computer Aided Instruction, Meta-Analysis.

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1. Introduction

Education is the common point that all countries in the world agree on. In a developing world all countries try to bring a new point of view to the education system. Instead of rote, unproductive and passive learning; productive, searching, innovative and active individuals are wanted to. The perception of traditional teaching methods has been left and the perception of growing student centered, information searching, free, productive individuals has become a more accepted approach in education (Akçay et al, 2007; Akbulut et al. 2008; Acar, 2011). Today, traditional teaching method's inability to respond to the expectations bring about the necessity of change in the education system. In this situation, there has been a need for using technology to change the education. One of the new technologies discussed is computers which is the most effective communication which do self-education device vision (Camnalbur, 2008). People's adapting to gradually complicating community, teaching and learning activities' regulation to meet necessities of the individuals and to make it productive, making use of computers in education and at the same time evaluating individuals' attitude towards computers has become imperious (Hannefin & Peck, 1988; Acar, 2011).

Use computers in the field of teaching and learning has brought about the concept of Computer Aided Instruction (CAI). CAI means use of computers to make students more successful in learning (Usun, 2004; Acar, 2011; Timmers et al. 2013). In other study definition, it is said that students' recognition of their mistakes and deficiency via interaction, taking feedback and control of their own learning, to make students more concerned with the lessons with the help of graphics, sounds, animations and diagrams using computer can be called CAI (Baki and Birgin, 2004). The method of computer aided instruction is also accepted as a teaching method which is self-learning principles unifying with the computer technology (AbuSeileek, 2012; Celik & Yesilyurt, 2013).

Computer Aided Instruction is using computers in teaching and learning process in an educative environment. Teacher's realization the activities such as preparing the educational environment, recognizing the students' talents, individualizing appropriate to their talent, steering, training and repetition; requires the teacher to use the computer, according to the construction of the subject he/she will teach, the teaching aims he predetermined and use the computer in different place, time and ways (Ogut et al, 2004; Acar, 2011). However, its definition is, in CAI, computer's involvement in teaching environment is not an option to replace teachers but to complete the system and strengthen it is a basis (Usun, 2004; Akbulut et al. 2008; Acar, 2011; Celik & Yesilyurt, 2013).

Computer aided instruction's advantages in education have been observed (Cilenti, 1998; Deniz, 1992; Akbulut et al. 2008; Acar, 2011):

- 1- Provides students an individual learning with their learning speed and their own perception,
- 2- It is a device which doesn't bore student,
- 3- It is motivating and reinforcement for students who should answer so quickly,
- 4- By composing music, using colours, movements, and diagrams, it provides students the chance to have real life experiences,
- 5- As it has the talent of keeping record it makes self-learning easier and provides the chance to observe the progress of the students,
- 6- Provides the teacher the opportunity to keep all the students under control in terms of education.
- 7- It is an effective motivational source for the new users.
- 8- Provides a secure information transfer among the learners in terms of place, source, time.
- 9- It broadens productivity and provides effective learning.

Besides increasing the success computer aided instruction provides upper level thinking among students which is why students learn by grasping rather than by rote learning is observed (Renshaw and Taylor, 2000).

Computer Aided Instruction's disadvantages has been described as follow:

1. In computer aided instruction students' interaction with computers blocks the interaction among the students, consequently students lack the socialization.
2. Students are expected to be perfect since there is a strict line between right and wrong in computer software. In this case, there is no mechanism to encourage students and steer them to the right.

3. Working by using computer is absolutely harder than turning the pages of the books. Therefore, the students who will have a computer aided instruction have to get the education of literacy in computers beforehand (Cilenti, 1998; Acar, 2011).

In education with CAI some of the behaviours aimed are perceptive some are cognitive. Some of the perceptive behaviours aimed are about the attitudes. Knowing how many of the aimed behaviours achieved can only be possible with evaluating the attitudes which are believed to have improved (Oruc, 1993; Acar, 2011).

Attitudes have a decisive effect on behaviours with experiences and intellectual, social and emotional components. For example; people's attitudes towards computer consists of their feelings, beliefs and plans (Topcu, 2009; Gürbüz & Birgin 2012).

1.1. The problem of the study

In Turkey in order to determine the efficiency of the computer aided instruction, meta analytical effect analysis is needed. From this point of view, effect size of the lessons' with computer aided instruction effect on student attitudes has brought about to see the whole picture has been the problem of our study. An answer to the question was that when experimental studies related the topic in the literature compared with traditional teaching method in branch education, does computer aided instruction method have a positive effect on students' attitudes? (Acar, 2011; Timmers et al. 2013).

1.2. Objective of the study

It is to determine computer aided instruction method's effect on students' attitudes. It is aimed to make a meta-analysis study in order to determine the effect of computer aided instruction method on students' attitudes towards lesson's common effect gravity in science and mathematics education.

2. Method Meta-Analysis

Method was used in this study. Meta-analysis is briefly analyze of the other analysis. It gathers the other studies results together in a consistent and harmonious way (Cohen, 1988, Ozcan, 2008). Meta-analysis is a statistical method in which a branch's similar studies' results are used to join them together. (Ergene, 2003; Yesilyurt, 2010; Acar, 2011). The sorts of meta-analysis are grouped in two main topic and two sub-topics (Durlak, 1995; Yesilyurt, 2011).

1. Group contrasts

1.a. Treatment effectiveness

1.b. Group differences

2. Correlational association

2.a. Test validity

2.b. Variable covariation

Gathering studies' results together statistical models has been effective:

- Fixed effect model
- Random effects model

The fixed effect model is preferred in the studies which is thought to affect exactly the same, when the studies are not homogeneous random effect model is preferred. In order to collect data in the meta-analysis study, a research has been done beforehand with the Turkish and English key words in internet environment called "Turkish Council of Higher Education National Thesis Center". As a result of the study which is done with the key words such as "attitude", "computer aided instruction", "computer aided education", "computer aided physics, chemistry, biology, mathematics education", "students' attitudes towards computer aided instruction" 142 Masters of Science and PhD thesis and 45 articles and pronouncement totally 187 studies were reached. Among these studies 56 studies which are appropriate to be involved are brought together with meta analyses method (Acar, 2011; Yesilyurt, 2012).

Completing the study's samples, experimental researches and thesis were preferred. Codification was done according to this. Consequently 56 researches and 77 statistical data which could be used in this research was acquired. Under which circumstances the collected data could be involved in the research is listed below:

- Studies must be done in the last 10 years (2002-2011),
- Studies must be published thesis, involved time-bound academic magazines, online academic magazines, other databases, academic studies presented in congress and announcement,

- There must be control and experiment groups in the involved study, besides control group must present the classes which use the traditional teaching, and experiment group must present the ones which use computer aided instruction,
- Besides, t test must be conducted in the study,
- In experiment and control groups sample's size (N), average (M) and standard deviation (SD) values need to be given.

In this study, while analysing data, study effect meta-analysis method is used. The main aim in this study is to calculate the difference between the control and experiment groups in experimental study with the Formula $d=(X_e-X_c)/SD$ (Hunter and Schmidt, 1990; Sahin, 2005; Yesilyurt, 2012). However, in order to gather together statistical data which are in very different studies, firstly the data acquired need to be turned to a common measure unit, that means effect size (Sahin, 2005). In this study "Hedge's d" has been used to calculate the effect size. Effect size "d" is dividing the difference between the procedure with the two groups' united standard deviation (Topcu, 2009; Acar, 2011).

The answer of the question "much is it effective?" is taken thanks to the effect size in an incident examined in mass. All the effect sizes can be used for the situations below (Cohen, 1988; Yildiz, 2002; Acar, 2011).

"Cohen d" statistics is the effect size which define the standardized averages' difference, it shows how many standard deviations have the averages go away from each other, it replies which difference is actually bigger (Buyukozturk, 2009; Acar, 2011).

For effect size values which is based on the arithmetic average effect size classification is like below (Cohen, 1988);

- When it is 0,20 it has small effect.
- When it is 0,50 it has medium effect.
- When it is 0,80 it has large effect.

A more detailed classification can be done like the one below (Thalheimer ve Cook, 2002);

- $-0,15 < \text{Effect size value} < 0,15$ negligible,
- $0,15 < \text{Effect size value} < 0,40$ small,
- $0,40 < \text{Effect size value} < 0,75$ medium,
- $0,75 < \text{Effect size value} < 1,10$ large,
- $1,10 < \text{Effect size value} < 1,45$ very large,
- $1,45 < \text{Effect size value}$ is huge.

The dependent varieties in the study are the effect size about the student's attitude towards lesson. And the independent varieties are studying characteristics of the students. Studying characteristics are like the ones below:

1. The literacy of the students who participated in the experiment,
2. The place of the studies,
3. The number of the samples in the study,
4. Standard deviation of the samples in the study,
5. Common values of the samples in the study,
6. The year the study is done.

In order to make calculations and graphics, metamix 1.7 and Excel 2003 programmes were used in the meta analysis study.

3. Findings

In meta-analysis study, the studies which were done between the years 2002-2011 were involved. Out of 56 studies involved research 33 are master and 8 are PhD thesis, 15 are articles and announcements. From the studies involved in the meta-analysis study, 11 in Ankara, 1 in Balikesir, 1 in Bayburt, 2 in Bolu, 2 in Denizli, 1 in Diyarbakir, 3 in Eskisehir, 1 in Erzurum, 1 in Hatay, 1 in Kutahya, 2 in Kastamonu, 1 in Kayseri, 2 in Kocaeli, 1 in Cyprus, 2 in Konya, 1 in Manisa, 4 in Istanbul, 13 in Izmir, 1 in Samsun, 2 in Trabzon and 1 in Zonguldak were done.

Table 1. Studies' Effect Size Direction's Frequency and Percentages

Effect Size Direction		Frequency	Percentage
0	(Zero)	17	30,35%
+	(Pozitive)	39	69.64 %
-	(Negative)	0	0%

When looked at the studies' effect size direction, with 39 studies (%69.64) positive effect is observed (Table 1). In the research computer aided instruction method's effect on attitude is compared to the traditional teaching method's effect. When effect size is also considered, it is observed that computer aided instruction method is positively more effective than the traditional teaching method.

In this meta-analysis study, in order to calculate the difference between the experiment and the control groups in the study Mean Difference Effect Meta-Analyses was used. It was considered as necessary to transform different studies' data to a common effect size which is shown with MD.

Table 2. Effect size formulas and Transformation Table

Statistic	Effect size Formulas	(MD) Transformation	Explanation
Means	$MD = Me - Mc$		M_e =Experiment group's mean M_c = Control group's mean
Variance	$Sp^2 = \frac{(Ne - 1)Se^2 + (Nc - 1)Sc^2}{(Ne + Nc - 2)}$		N_e =Experiment group's subject size N_c = Experiment group's subject size S_e^2 =Experiment group's variance S_c^2 = Control group's variance

In table 2 transformation formulas are given for effect size (MD) (Yesilyurt, 2011; Acar, 2011). MIX Version 1.7 (Meta-Analysis Made Easy) pack programme was used in the meta-analysis of related studies' data recorded

Table 3. Studies Experiment and Control Groups' Number, Average, Standard Deviation Values Which are Unified with Meta-Analysis Method

Order	Writer	Date	N(e)	M(e)	Sd(e)	N(c)	M(c)	Sd(c)
Study 1	Guler, M. H. & Saglam, N.	2002	35	162,85	8,095	34	135,17	13,42
Study 2	Sulak, S. A.	2002	38	62,97	8,94	38	54,65	11,10
Study 3	Akcay et al,	2003	35	162,85	8,095	34	135,17	13,42
Study 4	Akcay et al,	2003	16	171,37	18,43	16	172,68	16,80
Study 5	Akcay et al,	2003	34	181,50	6,738	34	135,17	13,42
Study 6	Akcay et al,	2003	17	170,94	18,25	16	172,68	16,80
Study 7	Akgun, O. E.	2005	19	62,421	8,119	18	63,611	8,119
Study 8	Hancer, A. H. & Yalcin, N.	2005	29	168,41	16,79	29	148,862	13,80
Study 9	Tural, H.	2005	26	124,23	12,44	26	110,69	18,79
Study 10	Basaran, B.	2005	31	4,110	0,648	32	3,7375	1,034
Study 11	Sirabasi, A.	2006	22	27,09	6,82	23	20,91	6,82
Study 12	Zaman, S.	2006	29	77,79	15,31	18	81,50	12,33
Study 13	Akpinar, E.	2006	33	64,21	6,23	32	62,31	8,20
Study 14	Akpinar, E.	2006	30	62,50	8,24	28	59,96	7,33

Study 15	Akpinar, E.	2006	33	98,59	12,93	32	96,71	11,29
Study 16	Akpinar, E.	2006	30	96,16	20,95	28	94,92	13,22
Study 17	Demirkan, S. N.	2006	33	77,12	13,59	33	75,63	12,73
Study 18	Demirkan, S. N.	2006	17	56,23	24,06	17	52,52	24,25
Study 19	Tekmen, S.	2006	21	103,71	11,49	22	82,31	23,43
Study 20	Altunay, Y. A.	2006	25	80,6	1,72	25	72,8	2,09
Study 21	Olgun, A.	2006	72	3,4853	0,265	70	3,4273	0,265
Study 22	Goncu, H.	2006	24	81,416	11,93	28	61,928	10,05
Study 23	Celik, E.	2006	13	80,00	16,02	13	85,62	17,11
Study 21	Akcaý et al,	2007	35	185,00	4,35	30	139,66	10,59
Study 24	Akcaý et al,	2007	35	177,00	19,70	30	139,66	10,59
Study 25	Yesilyurt, S. & Kara Y.	2007	24	85,16	9,13	24	78,16	9,22
Study 26	Kahraman, O.	2007	114	3,42	0,95	139	3,63	0,92
Study 27	Kahraman, O.	2007	63	3,35	0,98	34	3,40	0,88
Study 28	Demirdag, B.	2007	28	79,46	5,80	28	74,50	7,76
Study 29	Tuysuz, C. & Aydin H.	2007	48	75,95	12,16	38	73,42	12,81
Study 30	Tuysuz, C. & Aydin H.	2007	50	86,32	9,64	45	75,88	12,90
Study 31	Tuysuz, C. & Aydin H.	2007	24	86,82	9,27	27	74,56	12,86
Study 32	Saricayir, H.	2007	35	268,51	6,092	33	272,700	5,389
Study 33	Aksoy, Y.	2007	22	50,50	13,72	21	45,71	9,7
Study 34	Kara, Y.	2007	24	59,250	8,659	24	58,625	6,920
Study 35	Ozel, S. F.	2008	54	66,77	6,04	51	64,74	6,59
Study 36	Tavukcu, F.	2008	64	3,44	0,36	64	3,31	0,37
Study 37	Can, S.	2008	23	109,65	7,65	23	105,17	5,42
Study 38	Can, S.	2008	15	101,53	4,69	15	95,20	7,33
Study 39	Aktumen, M. & Kacar A.	2008	23	105,04	16,28	24	101,21	13,38
Study 40	Uygun, M.	2008	34	64,44	13,51	36	65,69	15,17
Study 41	Cankaya, S. & Karamete, A.	2008	53	86,17	10,65	79	49,13	7,682
Study 42	Arslan, A.	2008	30	80,73	7,94	30	77,50	10,94
Study 43	Pilli, O.	2008	29	27,62	2,27	26	25,77	3,10
Study 44	Poyraz, S.	2008	18	45,85	10,40	19	40,94	8,33
Study 45	Poyraz, S.	2008	20	49,50	7,05	19	40,94	8,33
Study 46	Pektas, M.	2008	22	162,77	14,07	21	157,33	15,27
Study 47	Pektas, M.	2008	22	154,50	12,73	21	157,33	15,27
Study 48	Akcaý et al,	2008	16	225,77	8,743	16	169,556	8,049
Study 49	Akcaý et al,	2008	20	191,30	11,33	20	167,300	8,757
Study 50	Akcaý et al,	2008	16	196,88	4,428	16	169,556	8,049
Study 51	Akcaý et al,	2008	20	221,20	9,331	20	167,300	8,757
Study 52	Kutluer, S.	2008	12	95,9167	15,162	12	75,66	1,410
Study 53	Camli, H.	2009	32	63,09	11,04	30	60,36	8,22
Study 54	Cetin, O. & Gunay, Y.	2009	29	4,22	0,50	31	3,41	0,85
Study 55	Cetin, O. & Gunay, Y.	2009	13	4,50	0,38	16	3,23	0,83
Study 56	Cetin, O. & Gunay, Y.	2009	16	3,99	0,47	15	3,61	0,84
Study 57	Comek, A.	2009	30	233,97	22,08	31	229,33	16,35

Study 58	Comek, A.	2009	30	127,90	14,48	31	126,75	11,26
Study 59	Comek, A.	2009	30	125,50	15,60	31	117,42	10,81
Study 60	Dervis, N.	2009	55	109,05	14,43	55	92,65	25,37
Study 61	Karademir, E.	2009	53	77,54	16,13	53	67,67	16,81
Study 62	Yildiz, Z.	2009	23	65,08	17,33	23	56,47	12,85
Study 63	Kara, Y.	2009	24	79,00	11,54	24	78,16	9,22
Study 64	Oner, A. T.	2009	25	73,03	12,94	25	68,94	12,78
Study 65	Budak, S.	2010	30	124,13	3,30	30	123,63	3,32
Study 66	Balaman, F.	2010	32	82,44	9,04	32	71,84	14,84
Study 67	Ozkok, E.	2010	26	49,35	5,08	27	26,78	4,22
Study 68	Hangul, T.	2010	25	93,88	21,35	28	76,71	30,02
Study 69	Barutcu Akyar, K.	2010	31	3,86	0,58	30	3,49	0,50
Study 70	Ozkan, F.	2010	29	62,69	6,01	29	57,34	8,11
Study 71	Helvaci, B. T.	2010	32	59,34	8,40	34	50,88	13,98
Study 72	Helvaci, B. T.	2010	32	46,84	12,14	34	53,46	11,25
Study 73	Ergorun, O.	2010	32	69,56	25,12	30	63,26	18,51
Study 74	Ozdogan E.	2010	30	118,2	12,34	30	111,4	12,49
Study 75	Cetinkaya, M. & Tas, E.	2011	25	23,920	5,567	25	23,680	2,357
Study 76	Hirca, N. Calik, M. & Seven. S.	2011	21	59,2	5,7	21	50,0	11,9
Study 77	Yesilyurt, S. & Gul S.	2011	30	64,77	9,37	25	61,96	8,94

In table 3, the studies' which, are made between the years 2002-2011 and are appropriate for meta-analysis, number of samples, the averages of sample, standard deviation of the samples are given.

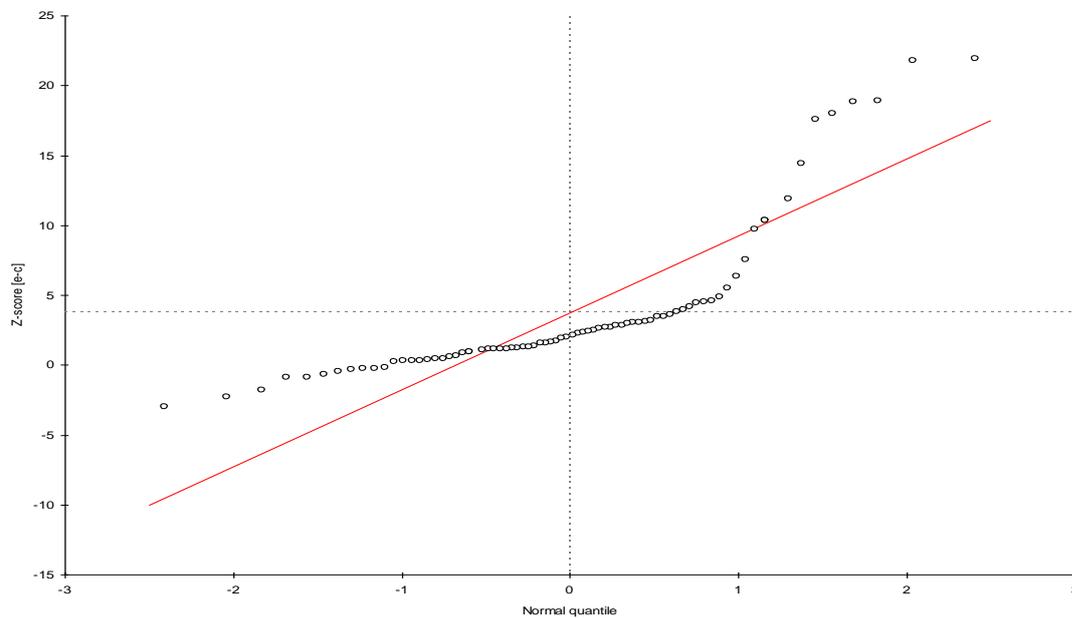


Diagram 1. Effect size's Q-Q Graph of Normal Distribution

In a meta-analysis study, effect size findings which are provided from different studies can be different. The important thing is not if there is any difference, it is if the difference is significant or not (Demirel, 2005; Acar, 2011).

In this meta-analysis study in order to determine the distribution of the effect size, heterogeneity tests were conducted. Normal distribution graph was formed like the diagram 1 with Metamix programme.

The unified studies' effect size, general distribution's being among the trust space along $X=Y$ line shows that it is close to the normal distribution (Rosenberg, et al, 2000; Acar, 2011).

As it is seen in diagram 1, serious deviations aren't observed in effect size. It is appropriate for normal distribution. This situation shows that unifying the studies used in meta-analysis study is statistically appropriate.

In order to evaluate statistical meaningfulness and homogeneity, z test calculations were conducted with Metamix programme and reached to $z=8,3048$. According to this with $p=0,000$, this conclusion was reached that the analysis is statistically meaningful, the data is homogeneous. Due to the data is homogeneous, constant effect data analysis method was preferred.

Table.4. MIX package programme meta-analysis findings calculated according to Constant Effect Model

Number of Study	77	
Z Test Value	8,3048	
H Value	6.5981	
Number of Attented Subject	4761	
Constant Effect	0,2627	Lower Limit-Top Limit
Meta Analysis Results		0,1812 - 0,3442
Q Value	3352,21	

As it is seen in table 4 the meta-analysis which is done in accordance with the constant effect model, $p<0,0001$ and 99 per cent confidence interval's lower limit 0,1812 and top limit 0,3442 average effect size $ES=0.2627$ was found and in field education computer aided instruction method has a positive effect on students attitude towards lessons conclusion has come out when compared to traditional teaching method.

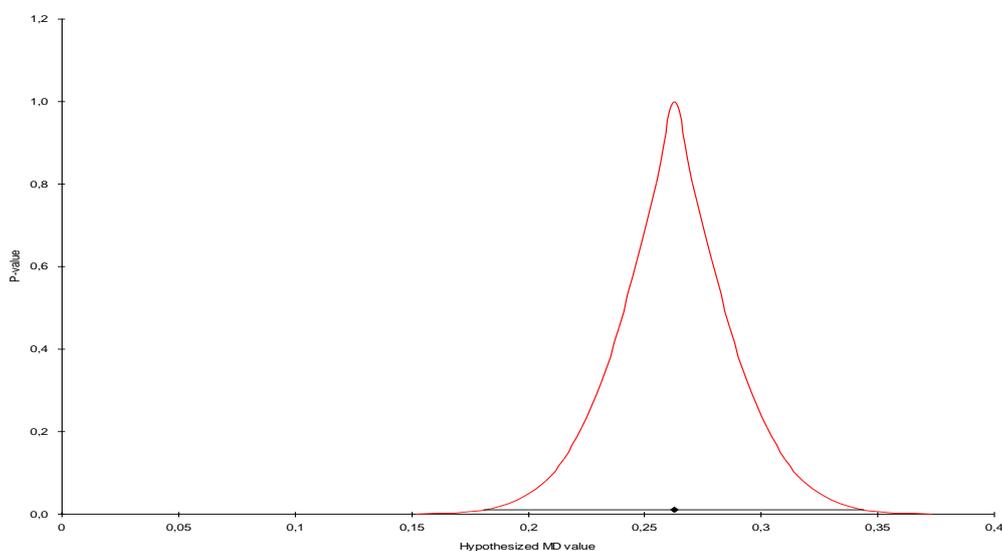


Diagram 2. Standardized Effect Size Histogram

In order to see effect size distribution, according to standardized histogram diagram in diagram 2 which is formed in Metamix programme, between 0,18 and 0,3 intervals, it is possible to say effect size regions are presented with high frequency. The graph of Effect Size (MD) and the Rejection Range is seen in diagram 3. The related distribution doesn't show symptoms of heterogeneous like any fluctuations and deviation.

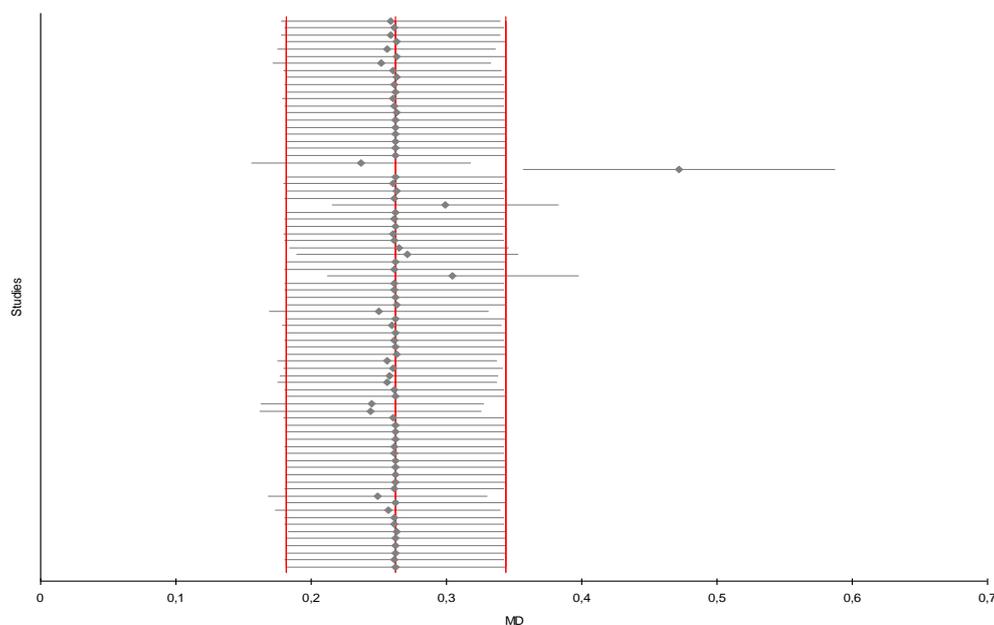


Diagram 3. Effect sizes and Rejecting Sensitivity Distribution

It can be said that computer aided instruction method applied in 77 data groups which are used in this analysis study has the common effect in terms of student's attitude.

4. Discussion

Out of the studies included in meta-analysis study using the ones related to science and mathematics fields caused the restriction in meta-analysis study. However, in the study fields CAI was compared to traditional method and was adequate to evaluate students' attitude towards lessons in science and mathematics.

In this meta-analysis investigation, the studies done after 2007 being more than the ones done before 2007 shows that the investigation is recent. Making investigation of elementary, secondary and university students shows that all grade levels included in. However, assuming all grade levels students' perception similar may seem problematic.

As a result of the analysis done getting into action with samples being homogeneous, using meta-analysis unifying method as a constant effect model, effect size was calculated and %99 confidence interval $E=+0.2627$ was calculated. This value between 0.18 and 0.34 which is found in the study although seen as medium scale effect, according to Thalheimer and Cook (2002) it has small effect is observed.

5. Conclusions

Most of the studies unified with meta-analysis method being done in near past time shows that the study is recent. Besides small number of the doctorate thesis searching attitude in the studies in research is taking attention. Making much more attitude search could be suggested in doctorate level.

According to the education level of the students used in the research when the frequency and percentage values are taken into consideration, it was observed that CAI is more effective for primary level students. Investigations in the study proved that computer softwares are benefited in science and mathematics fields. It is observed that simulation programs from computer softwares, were generally used in science while research and educative games programmes were preferred in mathematics field.

At the end of the meta-analysis $p<0.0001$ and 99 per cent confidence interval's 0,1812 lower limit and 0,3442 top limit average effect size $E=+0,2627$ was found. This numerical value has brought about the conclusion that in physics, chemistry, biology and mathematics fields CAI methods have changed the attitude of the students more in positive way when compared to traditional methods. According to the classification made by Thalheimer and Cook (2002) it was observed that it has small effect.

Additionally, it was come to conclusion that the study is consistent with the researches conducted in our country and abroad.

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