

META ANALYSIS OF THE COMPUTER ASSISTED STUDIES IN SCIENCE AND MATHEMATICS: A SAMPLE OF TURKEY

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ABSTRACT

Because of being a developed country which is a phenomenon among the countries in the world, this desire inevitably has contributed the scientific and technological developments in educational areas as well. The expectation of these scientific and technological changes reflections in teaching areas to form permanent learning has developed the use technology in education. The use of computer in educational areas increases in our country together with the developed countries. Computer assisted instruction is mostly used in academic studies that investigate the success of difference and it is known to use control and experimental groups in these experimental studies. Meta-analysis summarizes the results of various studies in the fields of science and aims at reaching common judgment by combining the conclusions. The purpose of this study is to obtain a general opinion about effectiveness of taught courses which are carried out by using Computer-Assisted Instruction in Science and Mathematics in our country by using meta-analysis method. That is, meta-analysis method was used to combine the similar studies and to determine the mean effect of the Computer Assisted Instruction (CAI). The most important result of this study is that the Computer Assisted Instruction has an important level of superiority.

INTRODUCTION

It has been a prerequisite for countries to become a more developed country in all areas than other countries in the world. Therefore, competition of production and consumption among the countries is an important area of activity which should be regulated not to damage the quality of social life. Providing of the dizzy technological development in the world to improve people's life quality in fast and permanent way should be the most important activity area of the countries. Moreover, it's thought that there are important contributions of results and suggestions of scientific researches in Science and Mathematics being integrated into the life of the communities on the basis of technological growth (Karalar and Sari, 2007). The expectation of these scientific and technological changes reflections in teaching areas to form permanent learning has developed the use technology in education.

Contributions of technology to educational areas are increasing to use of equipments and provide scientific researches to achieve positive results more quickly. It develops to use of technology in education that the expectation of this scientific and technological change's reflections in teaching areas which are aimed at making up more permanent learning. Similar developments are recorded in our country.

Therefore, the use of equipment, laboratory and computer in education is quickly replicated because of triggered developments in educational technology. Using computer in educational areas is growing up together with developed countries and it can be observed by looking at classrooms virtually in our country.

Technological applications in education have improved in various ways. The computer-use software in Science and Mathematics, computer use animations, computer use integrated experiment simulations are leading technological applications of performing important and permanent learning. Therefore, the use of computers provides significant contributions in Science and Mathematics. Apart from these, it has been seen that computers create statistical differences in experimental works which computers are involved as technology of providing support teaching areas.

In that case, Computer assisted instruction is a teaching method that has consisted of self-learning principles. Hence computer is used as a platform of learning to occur, to strengthen the process of teaching and student motivation. So, students can benefit from considering speeding up their learning by using computer technology. Computer assisted instruction can be defined as activities during which students are interacted with the courses that are conducted in computer. During the process teacher assumes the role of the guide and the computer assumes the role of the platform (Sünbül et al. 2002). Computer assisted instruction is mostly used in studies which use control and experimental groups and looked at the difference of academic achievement.

Meta-analysis can be described as analysis of analyses in the literature studies. Meta-analysis is a method analysis of analyses that combines the results of multiple studies which are made in a specific case and independent from each other. In so doing the statistical analysis findings obtained from studies are compared and combined. Meta-analysis summarizes the results of various studies in the fields of science and provides to reach

common judgments by combining the conclusions (Çağatay 1994; Abramson 1994; Akgöz et al, 2004). Therefore, meta-analysis is the method of combining the results of different studies.

Meta-analysis makes analysis of analyses of different studies which give statistical results in a similar way and in the same area in education. In other words, meta-analysis combines the results of studies which give quantitative results and makes analysis statistical results which are reached in these studies.

Various experimental researches in meta-analysis studies are being done in education. Teaching in many fields, especially in the studies which investigate academic achievement meaningful differences are found among groups. Important studies which are searched for meaningful differences between Computer-Assisted Instruction and traditional teaching are being carried out in our country in the fields of science and mathematics like other countries in the world. Meta-analysis of computer-assisted instruction applications and its effectiveness was calculated by Bayraktar (2000) in USA.

Problem of the Study

Is there statistical meaningful difference between two methods when Computer-Assisted Instruction applications in Science and Mathematics and experimental studies to measure effectiveness of traditional teaching which carried out between 2002–2008 in our country? This question composes the problem sentence of the research.

Purpose

The purpose of this study is to obtain a general opinion about effectiveness of taught courses with meta-analysis method which is carried out using Computer-Assisted Instruction in Science and Mathematics in our country. In addition, it's aimed to investigate whether or not a meaningful difference between Computer Assisted Instruction in Science and Mathematics and traditional teaching in our country when the experimental researches which are performed to consider academic achievement are considered.

Importance of Study

This study is important to determine the reason for doing the Computer-Assisted Instruction researches in academic achievement in literature. Also, doing meta-analysis of related researches and to be example of literature studies as being an analysis of analyses is important.

Limit of Study

In general, this study is limited to its own characteristics of meta-analysis method which is a method of literature research. The studies which are carried out Computer-Assisted Instruction application with experimental methods in Science and Mathematics between 2002–2008 in our country constitute the boundaries of this research.

METHODOLOGY

Chosen for this research and conducted in Turkey some Computer-Assisted Science and Mathematics studies have been examined. Review of these studies meta-analysis has been done to determine the mean effect of the Computer Assisted Instruction (CAI) in academic achievement. Shortly, meta-analytical screening method which allows to combine the results of similar studies in research and to calculate common effect sizes has been used (Ergene, 1999; Akgöz et al, 2004; Şahin, 2005).

Data Collection

Firstly, it's seen that the most important search criteria is CAI when considering the type of studies which may be related to this research. Therefore, the Computer- Assisted and Computer-Based content of the studies in Science and Mathematics has been collected to be used in research. In these studies, CAI is usually seen like activities prepared for correcting misconception, instead of laboratory simulation experiments and instead of basic expression of any unit various computer-based presentations which are supported by various visual. In teaching of Biology, Science and Technology, Physics, Chemistry and Mathematics areas, 155 studies whose content is CAI were compared between experimental and control groups. The collection of these studies has also been examined in term of whether or not CAI method contributes to students' academic achievement.

Process Order

It has regarded that experimental or quasi-experimental related studies have to be compared to determine academic success of students in terms of CAI. It has been decided that totally 25 studies are included in research having 't' or 'F' test findings. 2 of the studies are master thesis, 4 of them are academic paper and 19 of them are articles published in scientific journals. In addition, two different 't' findings in three studies and three different 't'

findings in one study were given. Thus, 30 different evaluable findings have been reached totally out of 25 studies.

Encoding process

The number of students, experimental group mean, standard deviation of the experimental group, control group mean, standard deviation of control group, t values and p values of 30 evaluable studies have been coded. In addition, publication date and the authors’ names of these studies were also included in the encoding. These encoding processes have also been done for pre-test findings of related studies. However, in a study Sünbül and his friends have done in (2002), although pre-test findings have been given for two different data, pre-test finding has not been given for third data.

Data analysis

Mean Difference Effect meta-analysis has been used in this research to calculate mean differences between experimental and control groups in experimental studies. It is seen necessary that data of different studies are converted to a common effect size indicated by MD.

Table1. Formulas of Effect Size and Table of Conversion

Statistics	Effect size (MD) formulas of conversion	Explanation
Means	$MD = Me - Mc$	Me=mean experimental group Mc=mean control group
Variances	$Sp^2 = \frac{(Ne - 1)Se^2 + (Nc - 1)Sc^2}{(Ne + Nc - 2)}$	Ne=participants experimental group Nc= participants control group Se ² =variance experimental group Sc ² =variance control group

The conversion formulas are given in Table 1. for Effect Size (MD). MIX-Version 1.7 (Meta-Analysis Made Easy) package program was used in the meta-analysis of the recorded data from related studies.

Findings and Discussions

Total of 30 data sets of 25 experimental researches which are suitable for determining criteria and to measure effectiveness of the CAI studies conducted in our country were combined with meta-analysis method. Numerical and graphical results are listed for 30 data set of 25 related experimental studies.

Table 2. Meta-analysis findings calculated with MIX package program.

Heterogeneity	df	Mean Effect Size (Meta-Analysis Outcome)	99% CI
Q total 259,8178	29	E++ 3,8383	3,3745 to 4,3020

Findings of the heterogeneous test are seen in Table 2. Accordingly, it is understood that related studies are homogeneous at the critical level of 0.01 and can be combined. Average Effect Size is the positive value of E + + = 3,8383 and Computer Assisted Instruction is seen more successful than traditional teaching amount the value of +3,8383.

Normal Quantile Plot

The plot looks like the normal distribution while distribution of data approach to X = Y line. It is understood that effect size data distribution approaches to x-y line that looks like the normal distribution on the graph in Figure 1. Getting an appearance similar to the normal distribution from effect size dataset graph sets thinking related data are suitable to use for calculation of the total effect size.

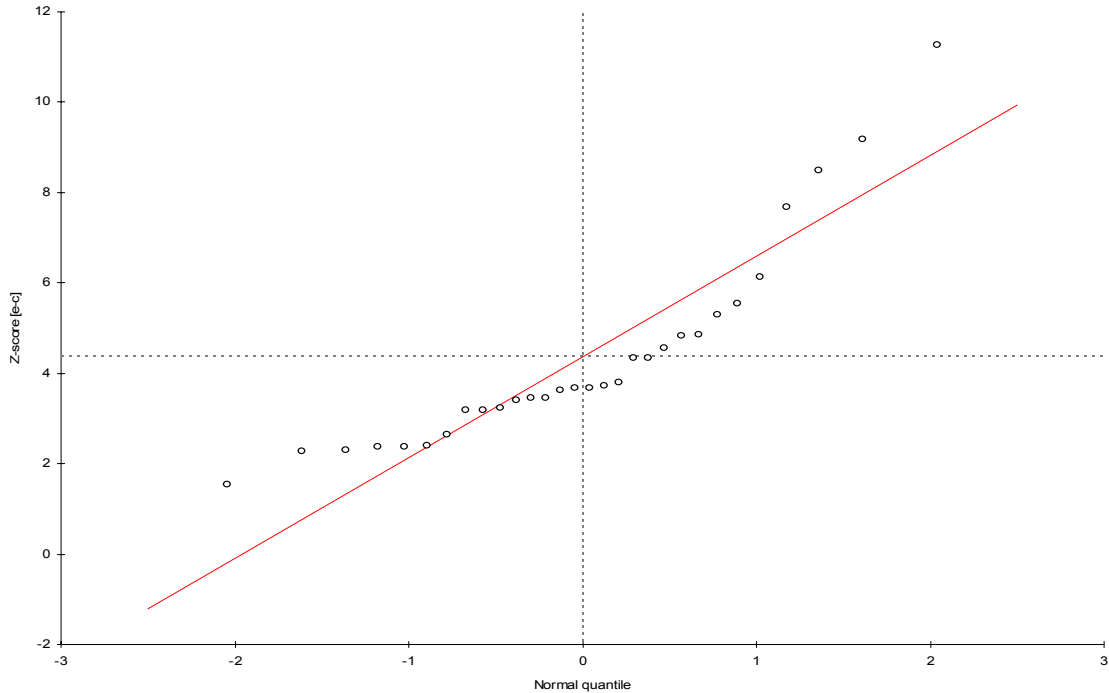


Figure 1 Normal Distribution Graph (Normal Quantile Plot)

Effect Sizes and Distribution of Rejection Sensitivity (Exclusion Sensitivity Plot)

The graph of Effect Size (MD) and the Rejection Range is seen in Figure 2. The related distribution doesn't show symptoms of heterogeneous like any fluctuations and deviation. Therefore, it's seen that data set of Average Difference Effect Size is a research figure which has homogeneous properties. In addition, according to this chart it's clear that all the MD values are positive and as a whole has a consistent distribution.

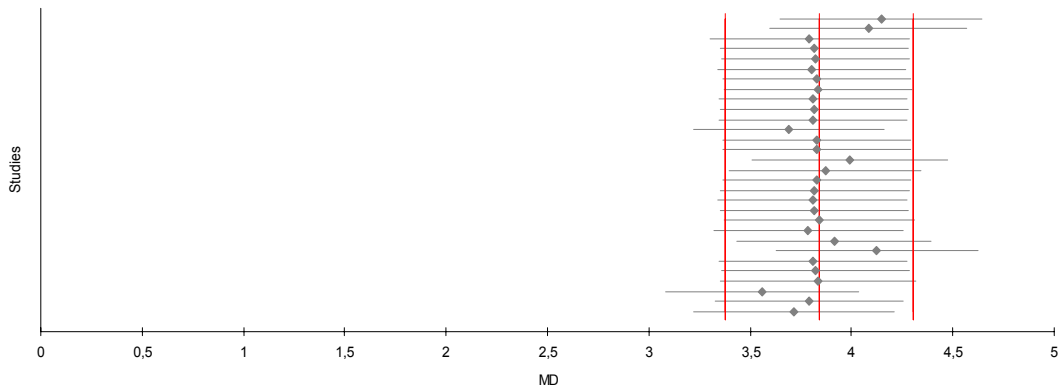


Figure 2. Effect Sizes and Distribution of Rejection Sensitivity (Exclusion Sensitivity Plot)

Mean difference levels, standard deviation levels and p values of related studies on committed meta-analysis are listed in Table 3. Accordingly only in one data group there is a p value greater than the value of 0.05 (Table 3. Study 8). Ozmen and Kolomuç (2004) measured student achievement with a test which can be evaluated two separate categories as multiple choice and open-ended questions on their study. In related study, two different data findings were listed and it's indicated that there isn't any significant difference between experimental and control groups in those t test findings which is given for multiple-choice questions. It is also seen in Table 3 that there is significant difference in favor of experimental group at the level of 0.05 between experimental and control groups in all the data sets of other studies. Thus, it's understood that data sets which are achieved from related studies can be combined and a common Effect Size can be given.

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

Study ID	Date	Referans	MD	99% CI	p
Study 1	2002	1	1,83	0,5606 to 3,0994	0,0002
Study 2	2002	2	1,37	-0,175 to 2,915	0,0224
Study 3	2002	3	4,21	2,7966 to 5,6234	< 0,0001
Study 4	2003	4	7,65	1,4433 to 13,8567	0,0015
Study 5	2003	5	21,45	6,3694 to 36,5306	0,0002
Study 6	2003	6	10,74	4,3661 to 17,1139	< 0,0001
Study 7	2003	7	7,48	-0,6252 to 15,5852	0,0174
Study 8	2004	8	4,35	-2,9522 to 11,6522	0,1249
Study 9	2004	9	17,19	7,4896 to 26,8904	< 0,0001
Study 10	2005	10	13,4	3,2341 to 23,5659	0,0007
Study 11	2005	11	19,96	9,3166 to 30,6034	< 0,0001
Study 12	2005	12	9,761	6,8032 to 12,7188	< 0,0001
Study 13	2005	13	7,48	-0,5889 to 15,5489	0,0169
Study 14	2006	14	9,86	-1,1361 to 20,8561	0,0209
Study 15	2006	15	2,161	0,5537 to 3,7683	0,0005
Study 16	2006	1	2,8	0,0789 to 5,5211	0,008
Study 17	2006	17	11,12	-0,9851 to 23,2251	0,018
Study 18	2007	18	11	2,2179 to 19,7821	0,0013
Study 19	2007	19	19,551	9,1514 to 29,9506	< 0,0001
Study 20	2007	20	20,54	8,3349 to 32,7451	< 0,0001
Study 21	2007	21	3,696	0,9325 to 6,4595	0,0006
Study 22	2007	22	14,22	7,608 to 20,832	< 0,0001
Study 23	2008	23	2,71	0,8667 to 4,5533	0,0002
Study 24	2008	24	1,86	0,5561 to 3,1639	0,0002
Study 25	2008	25	8	2,3072 to 13,6928	0,0003
Study 26	2008	26	12,29	2,3753 to 22,2047	0,0014
Study 27	2008	27	3,884	2,2492 to 5,5188	< 0,0001
Study 28	2008	28	8,592	6,6248 to 10,5592	< 0,0001
Study 29	2008	29	13,791	7,0915 to 20,4905	< 0,0001
Study 30	2008	30	4,74	3,4077 to 6,0723	< 0,0001

It should be known that if the statistical test for heterogeneity shows a low p value, the differences between the findings of studies can not be neglected. Therefore, the possible heterogeneity should also be examined visually at the same time while the p value is not very high. It's understood that study findings should be considered as homogeneous in situation of a heterogeneity test result at the level of significance $p=0.0001$. Thus, existence of only one single common effect can be defended in the findings of different studies with fixed-effect model. Namely, 30 data sets used in this meta-analysis have common effect in terms of CAI. The p value, Q value, E++ (Meta-analysis outcome) value and other relevant findings are reached from this meta-analysis given Table 4. The data about Q and E++ values are given and commented in Table 2. Here, it's seen that, critical level value $p < 0.0001$ is reached from the meta-analysis of 30 data sets. This critical level value reveals that experimental studies which are made for CAI and traditional teaching are supported. The obtained critical p value set to thinking that CAI studies both can be combined and can be considered to be preferred.

Table 4. Evidence Dissemination (meta-analysis)

Meta-analysis		Evidence dissemination bias	
General		General	
Number of studies	30	Current outcome measure	MD
Number of participants	2021	Current weighting method	IV
MD (IV) - Fixed effect model		Current model	Fixed effect
Meta-analysis outcome	3,8383	Original meta-analysis outcome	3,8383
99% CI lower limit	3,3745	99% CI lower limit	3,3745
99% CI upper limit	4,302	99% CI upper limit	4,302
z	21,3186	Effect assessment	
p-value (two-tailed)	< 0,0001	Rank correlation tau-b (continuity corrected)	#SAYI!
Heterogeneity		Ties	33,349398
Q	259,8178	P-Q (se)	177 (56,0506)
p-value (two-tailed)	< 0,0001	z	#SAYI!
H	2,9932	p-value (two-tailed)	#SAYI!
99% CI lower limit	2,4871	Regression method	Egger
99% CI upper limit	3,6023	Regressor weighting	None
I ²	88,84%	Intercept	3,3487
99% CI lower limit	83,83%	99% CI lower limit	1,6785
99% CI upper limit	92,29%	99% CI upper limit	5,0189
t ²	8,2327	p-value (two-tailed)	< 0,0001
		Sensitivity analysis	
		Fail-safe N	2546
		Tolerance level	160
		Trim-and-fill method (automatic)	L0
		Number of imputed studies	13
		Resulting meta-analysis outcome	3,4778
		99% CI lower limit	3,0217
		99% CI upper limit	3,9339

The participant numbers, mean values, standard deviation findings, working areas and numbers of 30 data sets used in this meta-analysis study are listed in Table 5. Accordingly, 10 science, 9 physics, 4 biology, 4 mathematics and 3 chemistry studies which have been carried out with Computer Assisted Instruction in our country in the year 2002-2008 have been included in this meta-analysis research. Moreover, e, c, N, M, SD abbreviations are respectively used instead of experimental group, control group, the number of subjects, mean and standard deviation values in Table 5.

Table 5. The subject numbers of studies, mean and standard deviation findings

Subject area	Study	N(e)	M(e)	SD(e)	N(c)	M(c)	SD(c)	
Study 1	Sciences	Sünbül et al. 2002	31	8,240	1,550	29	6,410	2,190
Study 2	Sciences	Sünbül et al. 2002	31	8,520	2,200	29	7,150	2,430
Study 3	Sciences	Sünbül et al. 2002	31	9,070	2,170	29	4,860	2,080
Study 4	Sciences	Çekbaş et al. 2003	22	70,900	7,960	20	63,250	7,650
Study 5	Sciences	Çekbaş et al. 2003	22	70,450	25,630	20	49,000	9,400
Study 6	Sciences	Yenice et al. 2003	35	76,450	12,590	35	65,710	7,470
Study 7	Sciences	Akçay et al. 2003	25	64,160	11,100	25	56,680	11,150
Study 8	Chemistry	Özmen & Kolomuç 2004	40	48,580	12,400	40	44,230	12,950
Study 9	Chemistry	Özmen & Kolomuç 2004	40	42,310	17,080	40	25,120	16,600
Study 10	Physics	Karamustafaoglu et al. 2005	25	41,120	17,239	25	27,720	9,603

Study 11	Physics	Saka & Yılmaz 2005	22	78,730	14,870	22	58,770	12,430
Study 12	Sciences	Aykanat et al. 2005	46	28,630	4,804	46	18,869	6,130
Study 13	Sciences	Akçay et al. 2005	25	64,16	11,0	25	56,68	11,15
Study 14	Biology	Pektaş et al. 2006	22	57,000	12,539	21	47,140	15,252
Study 15	Physics	Şengel et al. 2006	30	12,161	2,018	31	10,000	2,804
Study 16	Chemistry	Aydoğdu 2006	66	18,000	6,580	62	15,200	5,340
Study 17	Biology	Taş et al. 2006	26	70,810	18,370	27	59,690	15,680
Study 18	Physics	Şen (YL Tezi) 2007	8	30,120	4,010	8	19,120	8,770
Study 19	Physics	Hançer & Yalçın 2007	29	168,413	16,796	29	148,862	13,806
Study 20	Maths	Işık 2007	37	70,810	20,490	37	50,270	20,270
Study 21	Maths	Gökçül (YL Tezi) 2007	22	17,590	3,187	19	13,894	3,619
Study 22	Maths	Dilek et al. 2007	36	63,660	11,000	36	49,440	10,780
Study 23	Physics	Kert & Tekdal 2008	24	16,040	1,940	24	13,330	2,920
Study 24	Biology	Taşçı & Soran 2008	29	10,200	1,650	29	8,340	2,170
Study 25	Biology	Taşçı & Soran 2008	29	22,4	7,3	29	14,4	9,4
Study 26	Maths	Birgin et al. 2008	22	53,000	11,180	21	40,710	13,850
Study 27	Physics	Bozkurt 2008	35	10,427	2,726	35	6,543	2,582
Study 28	Physics	Bozkurt & Sarıkoç 2008	42	18,476	4,049	43	9,884	2,880
Study 29	Sciences	Demir & Kabadayı 2008	40	91,583	10,170	40	77,792	12,929
Study 30	Physics	Kara & Kahraman 2008	114	15,19	4,29	139	10,45	3,84

RESULTS

The purpose of this study was to obtain a general opinion about effectiveness of taught courses using Computer-Assisted Instruction in Science and Mathematics in our country with meta-analysis method. It has also aimed to investigate whether or not a meaningful difference between Computer Assisted Instruction in Science and Mathematics and traditional teaching.

It has been found that the total Effect Size $E^{++} = 3,8262$ and critical significance level $p < 0.0001$ values which were obtained from total 30 data sets of 25 studies used in this meta-analysis research showed the result that Computer Assisted Instruction was pretty much more effective than traditional teaching as academically have been reached. The common views of these studies which formed related data set were also restating the result of Computer Assisted Instruction's effectiveness.

The normal distribution graph of meta-analysis shows that the related data set is adequate and appropriate to calculate the total effect size. Moreover, effect sizes and rejection sensitivity graph gives that result, 30 data set doesn't show fluctuations, deviation and heterogeneous. Thus, the result that related data set is homogenous research figures was found.

The critical p value which is obtained in meta-analysis of related data set gives the result that Computer Assisted Instruction studies can be combined, supported and preferred.

It's seen that there are important contributions of results and suggestions of scientific researches in Science and Mathematics being integrated into the life of the communities on the basis of technological growth. Contributions of technology to educational areas are increasing to use of equipments and providing scientific researches to achieve positive results more quickly. The expectation of these scientific and technological changes reflections in teaching areas to form permanent learning has developed the use technology in education.

The computer-use software in Science and Mathematics, computer use animations, computer use integrated experiment simulations are leading technological applications of performing important and permanent learning. It's seen that computers create statistical differences in experimental works and computers are involved in teaching areas as technological equipment. In that case, computer assisted instruction is a teaching method that

has consisted from self-learning principles. It is used as a platform of learning to strengthen the process of teaching and student motivation. So, students benefit from fast learning process with computer technology.

Computer Assisted Instruction is getting attention of the teachers and its use is increasing continuously in our country. Our training institutions are also enriched rapidly by Ministry of National Education in term of computer hardware. It can be estimated that much more studies involved Computer Assisted Instruction can be enriched to increase valid and reliable literature with interest and equipment richness.

It has been understood that the result of meta-analysis studies were more solid and generalised. The most important result reached with the meta-analysis in this research was that Computer Assisted Instruction has an important level of superiority. The result of meta-analytic superiority achieved from these experimental studies in Turkey in favor of CAI shows compatibility with the results of meta-analysis research made by Bayraktar (2000).

SUGGESTIONS

In this meta-analysis research the result of Computer Assisted Instruction is more successful in academic term. However, it is not appropriate to make recommendations about all of the Computer Assisted Instruction because of especially ignoring qualitative research studies. Moreover, the post test findings can not be considered the only indicator of teaching. Thus, it has thought that supporting this meta-analysis in studies including qualitative researches can be useful.

Moreover, it can be thought that much more use of the meta-analysis researches will contribute to science because it is a literature method which can review and combine or compare related individual studies.

CAI can be suggested in situations of all educational institutions since it has been considered to have similar and useful results in these fields.

It can also be thought that quality of education and teaching will increase if educational planners and curriculum developers use Computer Assisted Instruction materials which are consistent with lesson types and contents.

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