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Efficacy of the Cooperative Learning Method on Mathematics Achievement and Attitude: A Meta-Analysis Research*

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Abstract
This research compiles experimental studies from 1988 to 2010 that examined the influence of the cooperative learning method, as compared with that of traditional methods, on mathematics achievement and on attitudes towards mathematics. The related field was searched using the following key words in Turkish "matematik ve işbirlikli öğrenme, kubaşık öğrenme, işbirlikçi öğrenme" and in English "cooperative learning and mathematics, meta-analysis." This study covered reports, articles published in refereed journals, and MA and Ph.D. theses. For the international literature review, advanced databases, such as ProQuest Digital Dissertations, EBSCO, and Eric, were mined. A total of 26 studies (n = 36) were considered in the meta-analysis. The effect size for cooperative learning on academic achievement was found to be d_{++} = 0.59 (95% CI: 0.38 between 0.80) and the effect size for cooperative learning on attitudes towards mathematics was found to be d++ = 0.16. In terms of achievement, the effect size was found to be medium, positive, and significant, but for attitude, it was small, positive, and significant. As a result, cooperative learning was reported to be a more successful method than the traditional method with regard to both achievements and attitudes.

Keywords: Cooperative learning method • Mathematic achievement • Meta-analysis • Effect size • Attitude

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In contemporary society, cooperation between groups and within groups has become important in line with scientific and technological developments. It is impossible to run a school or a company without collaboration (Şimşek, 2005). People and societies need to develop the behavior to work in collaboration with other people and countries. In our country, there are also attempts in various domains, particularly in education, to develop collaborative people. To practice the revised mathematics program, some of these collaborative principles have been adopted in education.

One of these principles is "collaborative learning" (Delil & Güleş, 2007). In collaborative classrooms, students are expected to discuss topics with each other, help and evaluate each other's knowledge, and compensate for each other's deficiencies (Açıkgöz, 2003; Slavin, 1995).

There has been a great deal of research on the efficacy of cooperative learning on mathematics achievement. Some of these studies have shown that the cooperative learning method has no effect on mathematics achievement (Altınsoy, 2007; Gömleksiz, 1997; Posluoğlu, 2002; Tanışlı, 2002), while others have shown a significant influence (Bonaparte, 1990; Bosfield, 2004; Karnasih, 1996; Nichols & Miller, 1994; Othman, 1996; Shupe, 2003; Spuler, 1993; Tarım, 2003; Ural, 2007; Ünlü, 2008; Yıldırım, 2006; Zenginobuz, 2005).

Scientific studies related to cooperative learning have been increasing (Açıkgöz, 2002). However, more comprehensive and reliable studies are required to evaluate this accumulated research to guide new research (Akgöz, Ercan, & Kan, 2004, p. 107; Şafak, 2008). Meta-analyses on prior research has shown that the findings in the related field have generally agreed with each other, so some generalizations based on these past studies have been possible (Akçil, 1995; Hunter & Schmidt, 1990, pp. 35-39; Hedges & Olkin, 1985). According to Glass (1976), there are three types of data analysis: primary analysis, secondary analysis, and meta-analysis. A meta-analysis is a statistical method that combines the data of at least two studies. In addition, a meta-analysis has been defined as an analysis of analyses, and focuses on relational, experimental and semi-experimental studies, and the regression results using quantitative techniques (Dinçer & Yavuz, 2013).

Purpose

The main aim of this study is to use a meta-analysis to synthesize the results of the experimental studies that have investigated the effects of cooperative learning on academic achievement in mathematics and on attitudes towards mathematics, in comparison to traditional methods. With regard to this general objective, the research questions were as follows: (*i*) What kind of effect does the cooperative learning method have on student achievement? (*ii*) What kind of relationship does the effect of cooperative learning method have on mathematics achievement in regard to the following variables?

- student grades
- sub-domains of mathematics (algebra, statistics and probability, geometry, measurement etc.)
- cooperative learning techniques
- experimental period
- whether the studies could be published.

(*iii*) What kind of an effect does the cooperative learning method have on student attitudes towards mathematics?

Method

The meta-analysis method was used in this study, which is an analysis of analyses and which combines several different research findings using quantitative techniques. According to Durlak (1998), there is no standardized methodology for meta-analysis studies but various methods can be used in line with the objectives of the research. In general, meta-analysis research is based on six main steps (Durlak, 1998): (*i*) determination of the research questions, (*ii*) a literature review, (*iii*) the coding of the studies, (*iv*) the production of an effect size index, (*v*) a statistical analysis of the distribution of the effect sizes, and (*vi*) results and conclusions. This study followed these steps.

Data Collection

Experimental studies from 1988 to 2010 that investigated the efficacy of cooperative learning on mathematics achievement and on attitudes towards mathematics and compared this efficacy with traditional methods were considered in this study. ProQuest, Digital Dissertations, Ulakbim, EBSCO, ERIC and Google Scholar databases were searched for the key words: in Turkish "matematik ve işbirlikli öğrenme, kubaşık öğrenme, işbirlikçi

öğrenme" and in English "cooperative learning and mathematics, meta-analysis." Reports, articles published in refereed journals, MA and Ph.D. theses were taken into account.

Studies based on pre-test/post-test design and focusing on comparisons among groups were chosen. In line with these criteria, 26 studies were considered for the analysis.

Criteria Followed for the Studies to be taken into Meta-analysis

The following criteria were followed to decide on the studies to be included in the analysis for this research:

(i) Reports, articles published in refereed journals, and MA and Ph.D. theses investigating the effect of cooperative learning on mathematics achievement

(ii) Studies with pre/post-test design and experimental studies with control groups or studies with equated groups were preferred

(iii) Studies with satisfactory background information for the calculation of the effect size (the sample size, standard deviation, and mean)

(iv) Studies conducted with students (pre-school, primary school, secondary school, and university students) and studies comparing cooperative learning methods for mathematics achievement and on attitudes towards mathematics to traditional methods

(v) Studies comparing cooperative learning methods to traditional methods (but not multiple intelligence based cooperative learning methods or computer assisted cooperative learning methods)

Dependent Variable

The dependent variables in this study were the effect sizes calculated from the data from the selected studies, and the independent variables were the characteristics of the studies (moderator variables).

Data Analysis

The effect size of each study was considered, and the combined effect sizes were computed using the MetaWin 2.0 Statistical Program (Rosenberg, Adams, & Gurevitch, 2000). According to Cohen (1988), the classification of effect size based on the mean is as follows: (*i*) if the effect size is around 0.20, then it is considered to be small, (*ii*) if the effect size is around 0.50, then it is considered to be medium, and (*iii*) if the effect size is around 0.80, then it is considered to be large (cited in Lipsey & Wilson, 2001). These classification values determined by Cohen are the most widely used to interpret effect sizes (Üstün & Eryilmaz, 2014). A random effects model was used to calculate the effect sizes (Wolf, 1986). In this study, the significance level was determined to be 0.05 for all statistical analyses.

Findings

Findings based on the Studies that were analyzed in terms of Achievement

In general, according to the random effect size model, the upper limit of the confidence interval was found to be 0.80, the lower limit was 0.38 and the effect size mean ES = 0.59. This indicated that the cooperative learning method was more influential than the traditional learning method for academic achievement. According to Cohen (1988), this effect size value was at the medium level. The kind of effect cooperative learning method had on mathematics achievement in terms of the moderator variables was also investigated.

The Efficacy of the Cooperative Learning Method in line with Student Grades:

Table 1
Effect Sizes based on the Grades of Students who Participated in the Experiments

Variable	Q^{*}_{B}	N	d_{+}	95% confidence interval for d	
				Lower	Upper
Education level	11.76				
Preschool		2	1.01	-4.89	6.93
Primary		10	0.50	0.09	0.93
Secondary		11	0.30	-0.09	0.70
High school		8	0.54	0.05	1.03
University		5	1.33	0.60	2.06

When the average effect sizes in Table 1 were considered, it was seen that the cooperative learning method was the most effective at the university level in terms of mathematics achievement (d_{+} = 1.33). For the effect among the different grades, significant differences were observed for the effect sizes of these five grades (Q_B = 11.76; p = 0.02).

The Efficacy of the Cooperative Learning Method for the Mathematics Sub-field:

Table 2
Effect Size Intervals in Line with the Sub-field on which the Experiment was based

Variable	Q_B	N	d_+	95% confidence interval for d	
				Lower	Upper
Sub-field	2.59				
Geometry		6	0.67	0.00	1.33
Numbers		14	0.46	0.08	0.83
Algebra		9	0.82	0.32	1.32
Undefined		4	0.64	-0.37	1.64
Measurement		2	0.19	-5.56	5.94

According to the classifications in Table 2, the highest effect size was found in the geometry sub-field (d_+ = 0.67) and for algebra (d_+ = 0.82). The lowest effect size was found in the measurement sub-field (d_+ = 0.19). For the differences among grades, no significant differences was seen among the effect sizes (Q_B = 2.59; p = 0.63).

The Efficacy of Cooperative Learning Techniques Used:

Table 3
Effect Size Intervals in Line with the Cooperative Learning Technique Used

Variable	Q_B	N	d_+	95 confidence interval for d	
				Lower	Upper
Techniques	3.26				
STAD(Student Team Achievement Division)		17	0.72	0.37	1.07
EKM (The Exchange of Knowledge)		5	0.37	-0.48	1.23
LT (Learning Together)		2	0.95	-5.49	7.40
TAI (Team-assisted Individualization)		3	0.55	-1.06	2.16
Unstructured		2	0.91	-5.73	7.56
Undefined		4	0.24	-0.59	1.09

With respect to the average effect size in the categories in Table 3, it was observed that the most effective cooperative learning method for increasing mathematics achievement was unstructured (d_+ = 0.91) and STAD techniques (d_+ = 0.72). For the effect among the grades, no significant differences were seen among the effect sizes for seven grades.

The Efficacy of the Cooperative Learning Method in Line with the Duration of the Experiment: The effect size differences for the duration of the experiment (3–8 week, 9–14 week, and 15–20 week) were considered. Similar effects were seen in these three classifications (d_+ = 0. 60; d_+ =0.68; and d_+ = 0.75). The effect among the grades found no differences for the average effect among the groups (Q_B = 1.12; p = 0.77).

Publication Bias

23 of the comparisons analyzed in terms of achievement were published sources (articles in refereed journals and reports) and 13 of these were unpublished studies (MA or Ph.D. theses). In this study, the average effect size for the published studies was d_+ = 0.44, whereas the average effect size for the unpublished studies was d_+ = 0.88. In terms of the effect among the grades, no significant differences were seen between the effect sizes of the published and unpublished studies (Q_B = 3.97; p = 0.70).

The Efficacy of Cooperative Learning on Attitude

7 studies focusing on the effect of cooperative learning on attitudes towards mathematics were included in the analysis. According to the random effects model, the upper limit of the confidence interval was found to be 0.52 and the lower limit was -0.20. The effect size value was ES = 0.6. These findings indicated that the cooperative learning method was better than the traditional method in terms of an increasingly positive attitude towards mathematics. The effect size value was considered as low in line with Cohen (1988).

Discussion

As a result of 36 comparisons based on 26 international and national studies conducted from 1988 to 2010, the general effect size was calculated to be d_{++} = 0.59 (95% CI = 0.38, 0.81). This indicated that the cooperative learning method was more influential on mathematics achievement in comparison to the traditional learning method. Following Cohen (1988), the effect size found was regarded to be medium. This finding is in line with the results in Tarım (2003), who compiled scientific studies in Turkey. She investigated the effect of cooperative learning on academic achievement in courses such as Turkish, mathematics, and science. She found the general effect size to be d_{++} = 0.82 and calculated the effect size especially on mathematics achievement as d_{++} = 0.52 (95% CI = 0.36, 0.75).

For the student levels, the efficacy of cooperative learning was observed at the highest level

at university and pre-school. However, the comparisons were found to be very limited at these levels. The hedge's d, which was used to calculate the effect size, gives secure results when used in 5 comparisons (Rosenberg et al., 2000).

Regarding the average effect in the mathematics sub-fields, the highest effect size was seen in geometry (d_+ = 0.66) *and algebra* (d_+ = 0.81). The lowest effect size was in the measurement sub-field (d_+ = 0.18). As the number of comparisons was limited, it was difficult to make comments on this effect size. It was also seen that studies in the field of statistics and the probability sub-field were very limited in Turkey and in the world.

Johnson, Johnson, and Stanne (2000) compiled 164 research findings which compared the eight cooperative learning techniques used mostly in meta-analysis studies (team-game-tournament, jigsaw, cooperation integrated reading, shared reading, student groups achievement parts, group assisted individualization, academic conflict, group research) to competitive and individual learning methods. As a result of this study, the following cooperative learning methods were ranked according to the efficacy level: shared learning, academic conflict, student group achievements, team-game-tournaments, group research, jigsaw and group assisted individualization, and cooperation integrated reading and writing techniques. In this study, when the techniques used in experimental studies using cooperative learning methods were examined, it was seen that the most effective cooperative learning method was found to be the shared learning technique (d_+ = 0.95), followed by unstructured techniques (d_+ = 0.91) and student group achievements (d_+ = 0.72).

In our study, it was found out that the influential techniques were shared learning (n = 2) and unstructured techniques (n = 2). The number of studies, however, that compared these techniques were very limited.

The scarcity of studies and the wide variety of techniques made the interpretation of the results difficult but there was an overall picture. With respect to the computed analyses, no significant differences were seen between the techniques in terms of the general effect size.

When the effect of cooperative learning on attitudes towards mathematics was taken into consideration, it was seen that the general effect size was low (d_+ = 0.16; n = 10). According to Freedman, Sears, and Carlsmith (1987) and Wiggins, Wiggins, and Vander Zanden (1994), students appeared to be resistant to attitude change. To overcome this, they suggested extending the duration of the research. In this study, the reason the general effect size was low for attitude may be because the experimental period in the studies taken into the analysis was only 5 weeks, which could be considered to be relatively short.

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Appendix 1
Codings of the Researches Used in the Meta-analyses

Number	Author	Publication Year	Grades	Time of experiment (Week)	Country	Technique	Sub-field	Effect Size
1	Tunay Bilgin	2004	Secondary	3–8	Turkey	STAD	Geometry	1.09
2	Dilek Tanışlı	2006	Secondary	3–8	Turkey	EKM	Numbers	0.23
3	İlhan Varank	2007	Primary	3–8	Turkey	LT	Numbers	0.25
4	Perihan Artut	2007	University	9–14	Turkey	Jigsaw II	Numbers	1.10
5	Alaattin Ural	2008	High School	3–8	Turkey	STAD	Algebra	0.96
6	Kamuran Tarım	2008	Preschool	9–14	Turkey	STAD	Undefined	0.40
7	Perihan Artut	2009	Preschool	9–14	Turkey	Unstructured	Numbers	0.31
8	Tayfun Tutak	2010	Secondary	3–8	Turkey	EKM	Numbers	0.00
9	Vesile Yıldız	1998	Preschool	9–14	Turkey	LT	Numbers	1.86
10	Nesi l Yantır	2007	University	3–8	Turkey	STAD	Geometry	3.05
11	Senem Pınar	2007	Secondary	Undefined	Turkey	STAD	Measurement	0.00
12	Melihan Ünlü	2008	Secondary	3–8	Turkey	STAD	Statistics and Probability	0.81
13	Tülin Özsarı	2009	Primary	9–14	Turkey	STAD	Measurement	0.39
14	John Reid	1992	Secondary	Undefined	USA	Undefined	Undefined	0.64
15	Robert Slavin	1992	Secondary	Undefined	USA	TAI	Numbers	0.11
16	Kathleen F. Berg	1993	High School	3–8	USA	STAD	Algebra	1.05
17	Joe D. Nichols	1995	High School	9–14	USA	STAD	Geometry	-0.30
18	Fu Xin	1996	Primary	15–20	USA	Undefined	Numbers	0.33
19	Virginia Rider Valentino	1988	University	3–8	USA	STAD	Algebra	1.55
20	Emmet Christopher Dennis	2001	University	3–8	USA	STAD	Algebra	0.46
21	Elizabeth Garza De Verastegui	2004	High School	9–14	Mexico	Undefined	Algebra	0.81
22	Lisa M. Cline	2007	Primary	15–20	USA	Unstructured	Algebra	1.60
23	Cedrick D. Gilbert	2007	Primary	3–8	USA	The Move It Mathematics	Numbers	-0.06
24	Jada M. Conring	2009	Primary	3–8	USA	STAD	Undefined	0.46
25	Ece Özdogan	2008	Primary	3–8	Turkey	TAI	Numbers	0.56
26	Maurice Galton	2009	Secondary	3–8	UK	Undefined	Geometry	-0.87