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Research Article

The Effects of Cooperative Learning on Students' Mathematics Achievement, Mathematics Self-Efficacy and Mathematics Anxiety in High School Mathematics

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Abstract. The purpose of this study is to identify the effects of cooperative learning on students' mathematics achievement, mathematics self-efficacy and mathematics anxiety. This study employed a quasi-experimental design with pre-test and post-test. For this purpose, 112 students in 10th grade participated in our study to compare the cooperative learning method with traditional direct instruction method. These students has been selected through a random sampling technique, so that 56 students taught through cooperative learning, formed two experimental groups (girls group and boys group), and 56 students taught through traditional direct instruction, formed two control groups. Sample of the students were also equated on the basis of socio-economic status and achievement in the mathematics. Data were analyzed using ANOVA and ANCOVA to test hypotheses at 0.05 significance level. The results of this comparison show that cooperative learning has positive effects on students' mathematics achievement, improves the mathematics self-efficacy of students and reduces students' mathematics anxiety. In addition, the results of post-hoc pairwise comparisons show that cooperative learning has similar effects on mentioned variables for boy and girl students in experimental groups.

Keywords. Cooperative learning; Traditional direct instruction; Mathematics achievement; Mathematics anxiety; Mathematics self-efficacy

Mathematics Subject Classification (2020). 97D40; 97D10

1. Introduction

Cooperative Learning (CL) is one of the student-centered education approaches, which has emerged as an important area in mathematics education; and in recent years many of researches have been concentrated on this area. CL strategy exists when students work together to accomplish shared learning goals [13]. This strategy is an effective educational plan to improve the academic achievement of students. For cooperative groups, academic achievement is accomplished via promoting students' success, through sharing, supporting and encouragement. CL refers to a set of instructional methods in which students work in small, mixed-ability learning groups; the groups usually have four members, one high achiever, two average achievers, and one low achiever; The students in each group are responsible not only for learning the material being taught in class, but also for helping their group-mates learn [28]. The aim of a CL group is increasing and improving the group members' learning level. The instruction of supplement textbooks can be adjusted based on the CL activities to provide newly introduced skills and concepts for students.

CL is one example of an instructional arrangement that can be used to foster active student learning, which is an important dimension of mathematics is learning and highly endorsed by math educators and researchers. Students can be given tasks to discuss, problem solve, and accomplish [32]. In CL environments, students tend to enjoy mathematics, and this motivates them more to learn mathematics [14]. Several studies have indicated that learning' within cooperative groups is very effective in improving mathematics achievement and mathematics problem-solving abilities (see for example: [4, 6, 8, 10, 12, 16, 31–33, 35–37]).

According to Johnson and Johnson [13], there are five essential features that define CL as an instructional activity. These features are respectively: (I) face-to-face interaction, (II) individual accountability, (III) improving the interpersonal and small-group skills, (IV) group processing, and (V) positive inter-dependence. There are many different forms of CL, such as Teams-Games-Tournament, Jigsaw, Cooperative Integrated Reading and Composition, Learning Together, Student Teams-Achievement Divisions, Team Assisted Individualization, Academic Controversy, Group Investigation, etc. [11].

As Slavin [29], CL at first the teacher starts the lesson to provide an overall perspective, present new material, pose problems or questions for investigation, and clarify directions for the group activity. Then, students of class divided into some small groups, with at least four members in each group. Students of each group work together cooperatively, for the purposes of problem discussing, conjecture making, and analyzing suggested answers of group members. In this procedure, the teacher has a key role to guide and help his/her students.

In this paper, we examine the effect of CL on mathematics achievement, mathematics self-efficacy and mathematics anxiety of students. For this purpose, the rest of paper is organized as follows. In the next two sections the concepts of mathematics self-efficacy and mathematics anxiety are described. After that, the methodology of research is presented. Data analysis and results are provided in the penultimate section. Conclusion and discussion are summarized in the final section.

2. Conceptual Aspects

2.1 Mathematics Self-efficacy

There are several different obstacles in the process of students' mathematics learning. These obstacles have two general sources, the first one is within-mathematics and the other is outside-mathematics. According to Alamolhodayi [1], the source that is outer for math difficulties are either intra-personal or outer-personal; the math problems that have an intra-personal source are initiated from the students' personal characteristics in mental and learning processes, motivation and attitudes. Among the intra-personal elements which effect on mathematical achievement, we can mention to the motivational and the cognitive ones. Psychologists and educators have considered the effect of motivational factors in learning [18]. In order to show the relationship between motivational variables and achievement, Pintrich and De Groot [24] designed and analyzed an expectancy-value model. This model consists of three important components: expectancy, value and affection. The expectancy variable has been included some different components; most important of them are: perceived mastery, self-efficacy and control beliefs. In this paper, we concentrate on self-efficacy variable. Self-efficacy is one of the most important motivational beliefs for student achievement, which concerns beliefs about capabilities to complete some tasks or activities. More specifically, self-efficacy has been defined as individuals' beliefs about their performance capabilities in a particular context or a specific task or domain [5].

According to Pajares [22], student who have more confidence in their abilities to learn are better at monitoring their work time and modifying their learning strategy when necessary. Self-efficacy in mathematics differs from perceived ability or competence "I am good at math", in that it is a measure of children's anticipated success given their current capabilities "I can master the skills in math this year, if I try" (see, Friedel *et al*. [7]).

Findings of many researches show that the CL improves self-efficacy beliefs in students (see, for example, [2,30]) nevertheless there is no significant study for surveying the effect of CL on the student's mathematics self-efficacy. One of objectives of this research is studying the effect of CL on the mathematics self-efficacy. The objectives of the work should be clearly stated as well as an adequate background.

2.2 Mathematics Anxiety

Nowadays, mathematics anxiety, as an important construct in mathematics education, has attracted the attention of many scholars, researchers and teachers. Mathematics anxiety is a negative effective reaction of students to situations involving mathematics concepts and calculations. Mathematics anxiety is a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations [26].

Not only can mathematics anxiety contribute to a person's self-concept of what one is capable of performing like in math, it is also responsible for one's choice of high school or college electives, college major and career choice as well. Some like to refer to mathematics anxiety as a "learned

anxiety" that develops over years of schooling and difficulties in math and science [3]. Several studies have indicated that CL methods are very effective in reducing of test-anxiety and mathematics-anxiety ([15, 17, 21]). Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference. Only relevant modifications should be described.

3. Material and Methods

3.1 Participants and Procedures

Here, a sample of 112 students (56 boys and 56 girls) chosen. This sample selected randomly form all 10th grade students of public high schools in Sirjan (a city in Iran), at the academic year 2014/15. The sample was homogeneous with regard to students' mathematics achievement. This study has employed a quasi-experimental design with pre-test – post-test control group method to compare the groups. For this purpose, before anything else, each of boys and girls groups bisected to two experimental and control classes. As mentioned in Slavin and Karweit [31] students learn better in heterogeneous teams, consisting of students with different ability levels. For selecting the cooperative groups, in the experimental classes, students were classified, based on their previous knowledge, achievement pre-test scores and teachers' overall evaluations to high, middle, and low levels. Then, regarding these levels, heterogeneous teams formed, each team consists four students, one high, two middle and one low level student. After that, students of experimental groups taught through CL method and control groups taught through Traditional Direct Instruction (TDI), in a period of 10 weeks. All the mathematics subjects, for all groups, were trained by teachers with more than seven years of experience. Finally, a post-test were taken and the obtained data was analyzed using Variance and Covariance analyses (ANOVA and ANCOVA) in SPSS software.

3.2 Used Instruments

The instruments used in this study were: (a) Mathematics Achievement Test (MAT) and (b) Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ).

MAT: Researchers designed a MAT to measure academic success of tenth grade students. The items in this test were determined according to the mathematics topics that are taught in this grade. The content validity of MAT was confirmed by experts of mathematics education. Also reliability status of this test checked using the retest method and reliability coefficient of Cronbach's was $\alpha = 0.83$.

MSEAQ: The questionnaire, with 5-points Likert's spectrum (from 1 = strongly disagree to 5 = strongly agree), consisted of two sub-scales: mathematics self-efficacy beliefs ($\alpha = 0.85$) and mathematics anxiety ($\alpha = 0.78$), that were adapted of [23] and [20]. This questionnaire was administered to students, as both a pre-test and a post-test. Cronbach's alpha for the two sub-scales self-efficacy beliefs and test anxiety which obtained by Pintrich *et al*. [23] was $\alpha = 0.93$ and $\alpha = 0.80$, respectively, and for two sub-scales mathematics self-efficacy beliefs and mathematics anxiety which obtained by May [20] was $\alpha = 0.93$ and $\alpha = 0.93$, respectively.

3.3 The Steps of Education

3.3.1 Executive Teachers' Training

Before implementing the study, the executive teachers received the necessary trainings for conducting the research in two sessions. At this step, the teacher's responsibilities, the advantages of using CL, CL methods, definitions of the research variables, the calculating method of the students' and the groups' scores, and also the average of each person were taught to them.

3.3.2 Class Training

As mentioned above first of all in experimental groups, the students were assigned into groups of four members (cooperative groups). In the control and experimental groups, the teachers presented the new lessons, according to their previous methods, while in the experimental groups, learning groups were formed at the end of each session and started studying the new lesson with together and teaching the materials to each other through group discussions; moreover, the group members tested each other. This method was used during this period and during all the math sessions. According to the time of conducting the study during the academic year, forty percent of the content of the high school mathematics I was taught using this method and the mathematics post-test was also designed and implemented, using this content.

3.3.3 Evaluation and Rating

A brief class test from the educational content presented during the week was designed and carried out in the last session of each week. After correcting the test papers, the scores were entered in the scoring forms. In these forms, each student had 10 average scores and 10 obtained scores from the brief implemented tests. The rate given to each group depended on the progress of each student in that group compared to his own previous performance average, which means that if the members of each group had progress in the new evaluation compared to their previous average, that would considered a rate for their groups. For example, if a student's last mathematics average be the score of 14, and he receives the score of 17 in the new test, he shows 3 points progress compared to his last score, and he adds 3 points to the group's rating and moreover, if each students' score was 18 or above 18, his current performance, regardless of his previous performance average score, added 5 points to the group's rating. These scores were entered in the scoring forms, and were reported to the students. Therefore the stronger students were encouraged to work better and also help the weaker ones.

3.4 Data Analysis and Results

In this study three hypotheses were tested:

(i) In comparison to students who are taught by traditional approach, students who are taught by CL approach have more achievement in mathematics.

(ii) In comparison to students who are taught by traditional approach, students who are taught by CL approach have more mathematics self-efficacy.

(iii) In comparison to students who are taught by traditional approach, students who are taught by CL approach have less mathematics anxiety.

To test the hypotheses and analysis of the data, single factor ANOVA and single factor ANCOVA were used. Students' post-test scores on the mathematics achievement test, responses to the mathematics anxiety questionnaire and mathematics Self-efficacy questionnaire were the dependent variables. Also, independent variable is teaching approach, with two traditional and CL methods, and pre-test scores were used as the covariate. For the sake of simplicity, we use the abbreviations EB, CB, EG and CG to experimental and control groups of boys and girls, respectively. Results of statistical tests are reported as follows.

3.4.1 Results for the First Hypothesis (Mathematics Achievement)

Table 1 presents the mean and standard deviations of pre-test and post-test scores for all groups. As seen in this table, the pre-test mean scores of four groups on the MAT are nearly equal, on the other hand the post-test mean scores, of both experimental groups, are slightly higher than the mean scores of the control groups.

Table 1. Students' Pre-test and post-test mean scores in MAT

Groups	Pre-test			Post-test	
	N	Mean	SD	Mean	SD
EB	28	12.8	2.83	14.50	2.68
EG	28	12.27	2.18	14.69	2.16
CB	28	11.69	2.09	11.91	2.12
CG	28	12.38	2.52	12.78	2.53

In order to test the homogeneity of groups, a one-way ANOVA was performed on pre-test MAT scores. The results, shown in Table 2, indicate that the differences between pre-test mean scores of four groups was not statistically significant ($F(3,111) = 0.436$, $p > 0.05$, n.s.).

Table 2. Comparison of students' pre-test MAT scores using ANOVA

Source	Sum of square	df	Mean square	F-ratio	p
Between groups	7.694	3	2.565	0.436	0.728*
Within groups	635.029	108	5.880		
Total	642.723	111			

*: Statistically significant at 0.05

Results of one-way ANOVA on post-test scores (Table 3) showed that there is a statistically significant overall difference between the mean scores of experimental and control groups ($F(3,111) = 8.964$, $p < 0.05$). To provide specific information on which means are significantly different from each other, a post-hoc pairwise comparison (Bonferroni) between the groups was done. Details of this comparison have been presented in Table 4. Results show that the difference between mean scores of EB and CB and also between EG and CG, are statistically significant

($p < 0.05$), therefore first hypothesis of research is confirmed. But there is no statistically significant difference between the mean scores of EB and EG ($p > 0.05$), as well as CB and CG ($p > 0.05$). Consequently, in the CL strategy there is no difference between the mathematics achievement of boys and girls.

Table 3. Comparison of Students' post-test MAT scores using ANOVA

Source	Sum of square	df	Mean square	F-ratio	p
Between groups	153.524	3	51.175	8.964	0.000*
Within groups	616.596	108	5.7090		
Total	770.120	111			

*: Statistically significant at 0.05

Table 4. Bonferroni pairwise comparisons

	Mean difference	p		Mean difference	p
EB vs. EG	−0.18	1.000	CB vs. CG	−0.87	1.000
EB vs. CB	2.59*	0.001	EG vs. CB	2.78*	0.001
EB vs. CG	1.72*	0.049	EG vs. CG	1.91*	0.021

* Statistically significant at 0.05

3.4.2 Results for the Second Hypothesis (Mathematics Self-efficacy)

Since MSEAQ was applied for measuring the mathematics self-efficacy and mathematics anxiety in both of pre-test and post-test, we used ANCOVA for controlling the effects of pre-test, as a covariate variable. Details of ANCOVA have been abbreviated in Table 5 and Table 6. Results indicate that the adjusted post-test mean scores of the cooperative instruction groups for mathematics self-efficacy is significantly ($p = 0.000$) higher than the adjusted post-test mean scores of the TDI groups; therefore the second hypothesis of research is confirmed. Also, as it seen on Table 6, the mathematics self-efficacy mean scores of students in the EB and EG groups are significantly more than those in the CB and CG groups, but the mean difference between EB and EG is not statistically significant. Therefore, there is no significant difference in mathematics self-efficacy between boys and girls groups, when learners are taught using CL strategy.

Table 5. Results of ANCOVA for the mathematics self-efficacy post-test

Source	Sum of square	df	Mean square	F-ratio	p
Pre-test	0.397	1	0.397	0.018	0.894
Group	3985.610	3	1328.530	59.690	0.000*
Error	2381.250	107	22.250		

*: Statistically significant at 0.05

Table 6. Result of the Post Hoc pairwise comparisons for the mathematics self-efficacy post-test

	Mean difference	p	Adjusted Mean Scores	Direction
EB vs. EG	−1.03	0.449	EB : 54.98	(EG>EB)
EB vs. CB	12.74*	0.000	EG : 56.01	(EB>CB)
EB vs. CG	10.08*	0.000	CB : 42.23	(EB>CG)
CB vs. CG	−2.66	0.069	CG : 44.90	(CG>CB)
EG vs. CB	13.78*	0.000		(EG>CB)
EG vs. CG	11.11*	0.000		(EB>CG)

*: Statistically significant at 0.05

3.4.3 Results for the Third Hypothesis (Mathematics Anxiety)

In order to test the third hypothesis, we use ANCOVA on mathematics anxiety of Experimental and control groups, Table 7 and Table 8. Result of the Post Hoc pairwise comparisons for the mathematics anxiety post-test show details of this test. Results indicate that the adjusted post-test mean scores of the cooperative instruction groups for mathematics anxiety is significantly (p = 0.000) less than the adjusted post-test mean scores of the TDI groups. So, the third hypothesis is confirmed. Also, based on Table 7, the mean scores of mathematics anxiety of students in the EB and EG groups are significantly less than those in the CB and CG groups, but the mean difference between EB and EG are not statistically significant. Therefore, there is no significant difference in mathematics anxiety between boys and girls groups, when learners are taught using CL strategy.

Table 7. Results of ANCOVA for the mathematics anxiety post-test

Source	Sum of square	df	Mean square	F-ratio	p
Pre-test	23.846	1	23.846	0.783	0.378
Group	3811.940	3	1270.640	41.720	.000*
Error	3258.830	107	30.460		

*: Statistically significant at 0.05

Table 8. Result of the Post Hoc pairwise comparisons for the mathematics anxiety post-test

	Mean difference	p	Adjusted Mean Scores	Direction
EB vs. EG	0.313	0.835	EB : 23.25	(EG<EB)
EB vs. CB	−10.08*	0.000	EG : 22.94	(EB<CB)
EB vs. CG	−12.69*	0.000	CB : 33.33	(EB<CG)
CB vs. CG	−2.61	0.087	CG : 35.94	(CG>CB)
EG vs. CB	−10.52*	0.000		(EG<CB)
EG vs. CG	−13.02*	0.000		(EG<CG)

*: Statistically significant at 0.05

4. Discussion

The main purpose of this research was studying the effect of CL on students' mathematics achievement, mathematics self-efficacy and mathematics anxiety. Findings indicated that CL has significant effect on students' performance in mathematics. In fact, obtained results emphasized that student' mean scores in mathematics achievement post-test, for the experimental groups, increased due to the effects of CL. This result on mathematics achievement corroborates results of many previous researches conducted on CL (see, for example, [4,9,32–34,36,37]). A probable reason for mathematics achievement in CL is that, when students share concepts, definitions and explanations with each other in groups, they retain mathematics subjects much longer in their memory. Also, interactive and encouraging features of CL improve the students' mathematics performance.

Also covariance analysis on mathematics self-efficacy scale indicated that the students who are taught in CL acquire more mathematics self-efficacy compared with students who are taught in traditional method of learning. According to Bandura [5], the students with higher self-efficacy are more successful and show more effort compared to those with lower self-efficacy. As the results showed, we believe that in cooperative groups no one is to blame and what is desired is the group performance itself. In this case given that group progress leads to the individual progress, the students choose the challenging and difficult tasks and deal with them, so it reinforces the students' self-confidence and consequently their self-efficacy beliefs and ultimately improves the students' academic achievements. We believe that the way students think about themselves in that whether they have weak or strong mathematical ability, will very clearly affect their performance and CL can boost and reinforce the positive belief in mathematics among the students.

This positive effect of CL method on students' mathematics self-efficacy was as a result of its positive interdependence attribute, which made it possible for students to see that their success is dependent on their contributions, help seeking, and success of the other students in the group. On the other hand, students in CL groups will be able to exchange their ideas on given tasks and concepts among their teammate, and this made it possible for students with low intellectual ability and slow learners to learn mathematics concepts from members of their groups. Hence, they became more confident and felt secured participating actively in mathematics lessons and observing successful students can increase self-efficacy of weak students. There is no significant research in effect of CL on mathematics self-efficacy, nevertheless there are some researches in this field have been done on other subjects, for example works of Araban *et al*. [2], and Queenie *et al*. [25] in English subject, Robertson [27] in statistics, and also Mari and Sani [19] in Chemistry.

As another result, findings of this study implied that CL has significant effect on mathematics anxiety of students, such that in comparison to students who are taught in traditional method, the students who are taught in CL have less mathematics anxiety. Perhaps the reason is that, in a CL environment the process of learning is more important than the learning product and no one is criticized for lack of knowledge and learning, also students are not

compared with each other and do not compete against each other. Since learning mathematical concepts require an environment integrated with practice and effort, according to the results of this study, it seems that CL can provide such an environment. In such condition, the students in cooperative groups can give rise to their own learning and to the learning of the other members of their groups, since in cooperative groups, each student analyzes the subject matter from his own point of view and when each student presents his viewpoints in the group, the deep and meaningful learning will consequently happen in all of the students. It seems that if the students have deeper and more meaningful learning and master the test's subject matter; they would experience lower test anxiety.

Moreover, the CL leads to the creation of a real connection among the students with each other and with their teacher. This issue makes the students obtain the information which the possibility of having access to them in the condition of education in the traditional way was more difficult for the students. CL creates a pleasant atmosphere in the classroom that this feature makes the students more readily participate in learning activities, and it also makes meaningful learning take place in the students, that this will lead to lower mathematics anxiety in students. In cooperative groups, students are given the opportunity to learn complicated concepts of mathematics through asking from others, thereby raising the confidence in math learning ability reducing mathematics anxiety. Teaching method as an external stimulus has impact on the students' test anxiety and since CL is considered as an active teaching method, as the results of this study revealed, can reduce the math anxiety among the students. The findings of this study on mathematics anxiety are consistent with studies by Keramati *et al*. [15], and Lavasani *et al*. [17].

5. Conclusion

The effects of CL are significant on mathematics achievement, mathematics self-efficacy and mathematics anxiety between the students (boys and girls) in high schools in Sirjan, Iran. This study helped to advance our understanding on the practical contribution of CL as it positively affected students' mathematics achievement. This should provide a scenario of CL practices in mathematics classrooms in high school context. Teachers may apply the most suitable approach CL in their teaching instruction in order to enhance students' performance in mathematics. Results of this study emphasize on the direct effect of CL on increasing the mathematics self-efficacy and decreasing the mathematics anxiety, as two main variables in mathematics learning. Since there are situations where the students' mathematical behavior in those conditions are directly impressed by their beliefs about themselves and their potential abilities, it seems that it is better that a part of the training program be allocated to the presentation of the solutions to increase and enhance the students' efficiency beliefs and to reduce their math anxiety. Therefore, based on the findings of present study, teacher's must more pay attention to practical approaches such as CL and apply these methods in classrooms to improve cognitive and effective outputs of students.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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