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Connecting Research to Teaching

Cooperative Learning and Its Effects in a High School Geometry Classroom

DURING OUR EXPERIENCES AS HIGH SCHOOL MATHEMATICS teachers, we have discovered these three things. First, many high school students do not like to take mathematics courses. These students sometimes find that mathematics is boring and believe that it will be of no use to them after they graduate from high school. Stuart (2000) states that many people think of mathematics as something that causes stress and is unpleasant. Such students have high anxiety about learning mathematics and trying to succeed. Second, students have difficulty expressing their thoughts on paper or in front of their mathematics class. This phenomenon may occur because many traditional mathematics classrooms foster a competitive atmosphere among students (Johnson and Johnson 1989). Third, the students are not accustomed to taking an active role in learning mathematics. In light of these discoveries, we wanted to find a method of teaching high school mathematics classes that would help our students understand and enjoy the mathematics. In particular, we asked the following question: Would our students understand and enjoy mathematics more if we tried a cooperative learning approach rather than the traditionally taught teacher-centered method?

Many students are not accustomed to taking an active role in learning mathematics

UNDERSTANDING COOPERATIVE LEARNING

Roger T. Johnson and David W. Johnson (2000, p. 1) define cooperative learning as a "relationship in a group of students that requires positive interdependence (a sense of sink or swim together), individual accountability (each of us has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making and conflict resolution), face-to-face promotive interaction, and processing (reflecting how well the team is functioning and how to function even better)." Cooperative learning is important for developing communication skills and students' abilities to work together in a mathematics class. When cooperative learning occurs in the classroom, students not only learn mathematics but build with their peers personal relationships that they might not be able to form in a traditional classroom (Johnson and Johnson 1989).

When planning to implement cooperative learning in the classroom, a teacher must consider the following: individual accountability and group rewards, student preparation, and common difficulties.

Many researchers state that successful cooperative learning requires that students have both group goals and individual accountability (Leiken and Zaslavsky 1999). Many problems can be minimized if the teacher's reward system is structured so that students are individually accountable for their work while they collaborate with their peers for the success of the group (Lindauer and Petrie 1997). The use of group goals (particularly social goals) in cooperative learning provides the students with a reason to work together (Johnson and Johnson 1989). Requiring individual accountability ensures that each student benefits from the experience by increasing his or her mathematical understanding. It is a great way to make sure that everyone in the group does learn the new concepts. The success of the group in achieving its goals then depends on the success of each group member.

When forming groups, teachers must establish group goals, as well as a system that rewards success. Teachers can do so in many different ways. For

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example, team members can earn points or other rewards for their team by performing well on a test (Stevens, Slavin, and Farnish 1991). Since the success of the team depends on the learning of each student, this method reinforces the value of helping each group member achieve success (Stevens, Slavin, and Farnish 1991; Posamentier and Stepelman 1999). Cooperative environments, which reinforce group goals and individual accountability, help students care about the success of their fellow students, become better listeners, and value alternative methods for solving problems (Stevens, Slavin, and Farnish 1991).

Students must be prepared to participate in cooperative learning, and teachers must set the stage for successful cooperative learning experiences in their classrooms. Many people mistakenly believe that cooperative learning takes place whenever teachers have students work in groups during class. However, cooperative learning is only successful when members of a group perceive themselves as part of a team that together must reach a goal (Posamentier and Stepelman 1999). Since cooperative learning is based on the premise that students who work together are responsible for one another's learning as well as for their own (Lindauer and Petrie 1997), students must learn to listen to one another and to value the notion that more than one way of approaching a problem may be possible. Cooperative learning is a great learning strategy, but it does not happen without some preparation.

A teacher may experience some difficulties when implementing cooperative learning, and it will produce successful results only if teachers learn how to employ it in the classroom (Slavin 1990). Indeed, cooperative learning can be detrimental to students' learning. For example, weaker students may copy the work of better students in their group, and the result may be a decrease from what the weaker student would have been able to learn in a traditional classroom. Another potential difficulty is that teachers must be prepared to give up some of the traditional control that they may have once had over the activity in the classroom. While ensuring that students are on-task is necessary in cooperative classrooms, students working together do create more noise. A teacher may perceive this noise as an indication of a loss of control. Some teachers believe that they are losing control of the direction or path that the students take to reach a solution, since student inquiry and questioning often take a different direction than the one that the teacher has planned.

BENEFITS OF COOPERATIVE LEARNING

Research shows that the benefits of cooperative learning include increased academic achievement, better communication skills, and successful social and academic group interactions. Student achievement in cooperative-learning environments is higher (Slavin 1991; Stevens, Slavin, and Farnish 1991; Whicker, Bol, and Nunnery 1997). The effects of cooperative learning on student achievement are very impressive. Students achieve in a cooperative learning setting for many reasons. In those settings, students see a variety of other students in various stages of mastery of cognitive tasks, and peers provide support and assistance to one another. When students interact cooperatively, they like to explain their strategies to one another in their own words (Stevens, Slavin, and Farnish 1991). The students who are explaining can then understand the material more clearly. When students are required to explain, elaborate, and defend their positions to others, they may be forced to think more deeply about their ideas. However, students who are listening to the explanations of others are exposed to, and must think about, other approaches to a given task. Observing others and practicing in such settings help learners internalize the concepts that they are attempting to master or understand (Stevens, Slavin, and Farnish 1991).

One of the greatest benefits of cooperative learning is that it increases students' skills in communicating mathematics (Artzt 1999). This communication helps them better understand the subject matter. In fact, Johnson and Johnson (1989, p. 235) state, "If mathematics instruction is to help students think mathematically, understand the connections among various mathematical facts and procedures, and be able to apply formal mathematical knowledge flexibly and meaningfully, cooperative learning must be employed in mathematics classes." Cooperative learning promotes learning mathematics in an active way, rather than in a passive way (Johnson and Johnson 1989). Teachers encourage their students to explain their mathematical understanding because it forces them to evaluate, integrate, and elaborate their knowledge in new ways (Stevens, Slavin, and Farnish 1991). Students can learn best from one another when they are required to provide reasoning for their answers or explain how they arrived at the answers. Teachers who require students to reflect on how they answered a problem and explain or elaborate to the other students in the group help the entire group learn more and emphasize mathematical communication skills (NCTM 2000). Cooperative learning allows students to both give and receive elaborate explanations. They then learn more than students who simply get the correct answers (Stevens, Slavin, and Farnish 1991). Mathematical communication, which is sometimes difficult, is important for a student's development in mathematics. Leiken and Zaslavsky (1999) found that using cooperative learning encouraged students to be actively engaged in mathematical learn-

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ing and to communicate with one another about mathematics. High achievement was a result.

Another benefit of cooperative learning is that it allows students to experience working with others toward a common goal. Students increased their ability to use mathematics in their social interactions. Some of the short-term outcomes include increased learning, retention, and critical thinking (Whicker, Bol, and Nunnery 1997). Compared with the traditional individually competitive classroom, cooperative learning experiences promote higher levels of self-esteem for the students (Johnson, Johnson, and Holubec 1984; Johnson and Johnson 1989). Cooperative learning can reinforce a student's feeling of self-acceptance, whereas competitiveness can negatively affect self-acceptance, and individualistic attitudes tend to be related to basic self-rejection (Johnson, Johnson, and Holubec 1984). Students working cooperatively often enjoy the experience and believe that their classmates like them. This belief that they are accepted by others also allows the students to believe that they are more successful academically. This perception of success increases students' self-esteem.

The only difference was that the experimental group worked cooperatively

The long-term outcomes of cooperative learning include greater employability and career success (Johnson and Johnson 1989). Many employers value an employee who has skills in verbal communication, responsibility, initiative, interpersonal interaction, and decision making. All these qualities can be developed by experiencing cooperative learning. Thus, cooperative learning not only helps students with mathematics but also prepares them for life after they graduate.

OUR CONNECTION OF RESEARCH TO TEACHING: IMPLEMENTING COOPERATIVE LEARNING IN A HIGH SCHOOL MATHEMATICS CLASSROOM

Since little research exists on cooperative learning in high school mathematics classrooms, we decided to conduct an informal experiment. Our participants were students in two geometry classes that one of the authors of this article taught. The classes had similar academic ability. The study compared the grades and attitudes of the students in these two classes. In both classes, the students worked mostly independently during the first quarter. Both classes worked on the same lesson every day and had the same homework and tests. Cooperative learning was used sparingly in both classes throughout the first quarter. However, we began to help students develop their abilities to work cooperatively. The students learned how to work in groups; and from the individual work submitted for grading, we could tell that they understood what it meant to be individually accountable for their learning. During the first quarter, we analyzed the achievement of the two classes and compared them with each other so that we could verify that the groups were indeed similar.

During the last week of the first quarter, both classes completed a survey, given in **figure 1,** that measured the students' attitudes about cooperative learning and mathematics. The results of this Likert-style questionnaire showed that both the experimental and control groups agreed that cooperative learning was a positive learning strategy to use in mathematics class. The students had similar opinions about working in groups, and not much disparity occurred in their answers to the questionaire. The responses of the group that was to become the experimental group indicated that those students, as a group, liked mathematics slightly more than their counterparts.

During the second nine weeks of the first semester, one of the geometry classes became an experimental group and the other class was a control group. Students in the control group were basically taught the same way that they had been taught during the first quarter; however, they did not work in cooperative learning groups during the second quarter. We introduced a significant instructional change for the experimental group. This class was taught using cooperative instruction exclusively, and the students' desks were placed in groups of four. Other factors were the same in both classes. The experimental group was taught the same lessons as the control group, both classes were taught at the same pace, and they took the same tests and quizzes. The only difference was that the experimental group worked cooperatively.

As stated previously, two very important aspects of implementing cooperative learning are to provide group rewards and to reinforce individual accountability. The group rewards were explained to the experimental group on the first day of the second nine weeks. The rewards were based on individual performance on each chapter test. Since the students had similar ability levels, we first designated an acceptable minimum score of 90 percent for every test. If each student in the group scored 90 percent or higher on a chapter test, each student in the group received four extra-credit points on the test. This type of reward system encouraged students in each group to make sure that everyone in the group understood the material before a test. It reinforced the value of individual accountability and at the same time created the possibility of earning extra-credit points if everyone in the group did well on the test.

At the end of the second quarter, we compared the grades of the experimental class to those of the control class. The average grade for each class had increased from the first quarter to the second quarter. When comparing the first-quarter grades to the

second-quarter grades, the overall average second-quarter grade of the experimental group was 9 percent higher than that group's overall average first-quarter grade, and the overall average second-quarter grade of the control group was 4 percent higher than that group's overall average first-quarter grade. The experimental group also had a higher second-quarter average than the control group: 97 percent, as compared to 95 percent in the control group. **Table 1** and **table 2** show quarter grades for each student in both classes.

TABLE 1
Quarter Grades (%) for Control Group

Student	Quarter 1	Quarter 2
1	87	96
2	88	95
3	81	93
4	98	102
5	88	96
6	85	93
7	94	96
8	88	82
9	87	93
10	90	87
11	91	99
12	90	92
13	98	99
14	97	101
15	89	96
16	91	102
17	97	101
18	89	92
19	96	97
Mean	91	95

TABLE 2
Quarter Grades (%) for Experimental Group

Student	Quarter 1	Quarter 2
1	93	95
2	96	102
3	78	88
4	97	102
5	93	103
6	83	93
7	90	102
8	90	99
9	97	107
10	94	92
11	80	97
12	84	86
13	81	98
14	88	94
15	83	103
16	93	95
17	82	88
18	87	98
19	90	100
Mean	88	97

Please circle one of the following numbers in each of the questions below.

1. strongly disagree 2. somewhat disagree 3. somewhat agree 4. strongly agree

1. I learn more when I work in groups in math class.
   1 2 3 4
2. I like math.
   1 2 3 4
3. I like working on math homework alone.
   1 2 3 4
4. I like studying for math alone.
   1 2 3 4
5. I would rather work in groups when doing math homework away from school.
   1 2 3 4
6. Learning math can be fun and enjoyable.
   1 2 3 4
7. I dislike studying for math in groups.
   1 2 3 4
8. I feel more comfortable asking a student in my group for help rather than asking my teacher.
   1 2 3 4
9. I learn less when working in groups in math.
   1 2 3 4
10. I dislike learning math.
    1 2 3 4

Fig. 1
Attitude survey

Within the experimental group, ten students (more than half the class) increased their overall grades by more then 9 percent. One student in particular had an increase of 20 percent from the first quarter to the second quarter—from 82 percent to 102 percent. Cooperative learning certainly seemed to have a positive effect on the experimental group.

At the end of the second semester, students in the experimental group completed the same attitude survey that both groups had completed at the beginning of the year. We compared the scores of the experimental group's postsurvey with their scores from the presurvey to determine whether immersion in a cooperative group setting for the entire semester had changed their attitudes about cooperative learning. The students in the experimental classroom appeared to have an even more positive attitude toward cooperative learning by the end of the second semester. Overall, the survey

indicated that the students in the experimental group liked working on mathematics with one another and thought that cooperative learning could help them understand and learn mathematical ideas.

Cooperative learning has a positive effect on students' achievements

Our experience with trying cooperative learning in the classroom convinced us that cooperative learning has a positive effect on students' achievement and attitudes toward mathematics. We believe that our focus on providing for individual accountability and rewarding groups for realizing their group goals contributed to the success of this project. Each student in the class had a dual responsibility—to himself or herself and to the other members of the group. Rewards were given for both efforts. Our initial success has encouraged us to continue using cooperative groups in our classes, and we continue to see it as a successful method for teaching mathematics.

CONCLUSION

Cooperative learning has many positive effects in the mathematics classroom if it is properly implemented. Studies have found that if teachers have some kind of group reward system with provisions for individual accountability, cooperative learning can be successful. Teachers must also prepare students to work cooperatively by emphasizing the need for good listening skills and an openness to the ideas of others. An effective use of cooperative learning in the classroom can positively affect students' social skills, self-esteem, and intergroup relationships. Today, teachers have the resources to see that cooperative learning can work; but experience is the best way to truly understand it (Artzt 1999).

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