STUDENT DISCUSSIONS IN COOPERATIVE LEARNING GROUPS IN A HIGH SCHOOL MATHEMATICS CLASSROOM: A DESCRIPTIVE MULTIPLE CASE STUDY

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STUDENT DISCUSSIONS IN COOPERATIVE LEARNING GROUPS

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A DESCRIPTIVE CASE STUDY

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Dissertation

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ABSTRACT

Teachers want and need students to excel in the classroom. Cooperative learning is one method recognized to address this. Numerous researchers have shown that cooperative learning leads to improved skills in teamwork and communication in other fields (Johnson and Johnson, 2007; Slavin, 1995). Cooperative learning used in this study showed that the secondary math students benefited socially and academically through effective student communication.

This case study reported observational evidence concerning the patterns and experiences of student interaction in discussions within cooperative learning groups in several high school geometry classes. Developed from data collected in observations, audiotapes, and student journals/notebooks, a multiple-case study was used to examine the discussions of two groups of students in cooperative learning groups. Each group participated in three activities: Placemat, to build team camaraderie; Numbered Heads, to strengthen positive interdependence; and STAD, to ensure individual accountability.

Four patterns emerged when examining the data: change in attitude toward cooperative learning, the development of trust, group regulation, and the facilitation of math learning.

Students showed a more positive feeling toward cooperative learning, stated an increased appreciation for cooperative learning, developed trust in their group members, and were able to analyze what they were doing well and what areas needed work. Math

learning occurred when the students demonstrated how they solved problems by communicating using mathematical concepts and language.

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I would like to dedicate this culmination of many years of hard work, my dissertation, to my father-in-law, Tom Phillips. The time I spent with him during his unsuccessful bout with non-Hodgkins Lymphoma prolonged the life of my dissertation. Not a day of that non-working time was ill spent. That process made me reevaluate the priorities in my life: family first and dissertation second.

I love all of you. Thanks.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background of the Problem

In classrooms across the United States, teachers and students are having an ongoing battle over how to teach and assess mathematics. Second Mathematics Assessment of the National Assessment of Educational Progress (1981) reported that "For the 9-year-olds mathematics was the best-liked of the five academic subjects…and the least-liked subject of the 17-year-olds." Davidson's (1990) observation was that many, if not most, students came to perceive math as a system of techniques that someone else had invented, which they needed to memorize in order to get the right answers on a series of problems that were not particularly interesting to them, so they could graduate and stop studying mathematics. It is time to change how mathematics is taught.

In traditional mathematics instruction, the role of the teacher was essentially to transmit knowledge to, and validate answers for, students who were expected to learn alone and in silence (Davidson, 1990). If mathematics instruction was to help students think mathematically, understand the connections among various math facts and procedures, and be able to apply formal mathematical knowledge with flexibility and meaning, cooperative learning must be employed in the mathematics classroom (Johnson and Johnson, 1983). Traditional math instruction had been based on the assumption that

students were passive absorbers of information, who stored what they knew and then easily retrieved fragments as a result of repeated practice and reinforcement. The learning of mathematics had often been viewed as an isolated, individualistic matter. One sat alone with paper, pencil, and perhaps calculator or computer and struggled to understand the material or solve the assigned problems. This process was often lonely and frustrating. Perhaps it was not surprising that many students and adults were afraid of mathematics. In contemporary language, they were troubled by math avoidance or math anxiety. They often believed that only a few talented individuals could compete successfully in the mathematical realm, whereas most of humanity was fit only for a life of mathematical mediocrity or incompetence. Small-group cooperative learning addressed these problems in several ways (Davidson, 1990).

Young people had tremendous energy, yet school learning situations often required students to sit quietly and listen passively. The teacher would then have exerted strong control to keep the students quiet and focused on the subject matter; an inordinate amount of time was taken away from instruction and learning. Instead, couldn't students' energy levels be mobilized by engaging them actively in the learning process? Moreover, human beings had strong needs for contact and communication with others. Indeed, many students were motivated to attend school in order to be with their friends; they had a strong need to be accepted, to belong, and sometimes to influence others (Glasser, 1986). School discipline, however, was often designed to prevent students from talking to one another in class. In contrast, by setting up learning situations that fostered peer interactions, the teacher met a basic human need for affiliation and used the peer group as a constructive force to enhance academic learning.

As we neared the end of the first decade of the 21st century, it was obvious that communication and teamwork were needed in the mathematics classroom. Communication, an essential element of mathematics education, was a method of sharing ideas and clarifying understanding through conversation and active listening (NCTM, 2000). Teamwork involved attention to the goals of the group and to the social processes used to accomplish those goals (Maduschke and Grummon, 1996). Active learning required intellectual challenge and curiosity, which were best aroused in discussions with other students. Talking through math problems with classmates helped students understand how to solve the problems correctly. Students had more chances to explain their reasoning in small groups than in whole-class discussions. Most students were more comfortable speculating, questioning, and explaining concepts in order to clarify their thinking in small groups. According to Riel (1996), students were required to have the opportunity to be involved in cognitive situations which were similar to the real world of teamwork, such as the workplace.

Communication and teamwork were required in the contemporary workplace. Traditional notions of basic mathematical competence were outstripped by ever-higher expectations of the skills and knowledge of workers; new methods of production demanded a technologically competent work force. The U.S. Congressional Office of Technology Assessment (1988) claimed that employees must be prepared to understand the complexities and technologies of communication, to ask questions, to assimilate unfamiliar information, and to work cooperatively in teams (National Council of Teachers of Mathematics [NCTM], 2000). According to Hoover (2002),

> . . . education (must be provided) in teamwork, leadership, communication, problem-solving, and decision-making. In a work environment that focuses on teamwork, each employee must be concerned with not only (his) teammate's right of space, but also with their right to their own opinion, and their right to make decisions. (p. 32)

Because the business community often measured success in handling intricate problems by the end product, team members who demonstrated the necessary skills were recruited from employees or new hires (Michaelson, Knight, and Fink., 2004).

Though necessary in the mathematics classroom, communication and teamwork were lacking. Kagan (1994) questioned how students could obtain skills like adjusting behavior to work effectively with others if they were not allowed to work together. According to The U.S. Department of Labor (Confessore, 1992), studies of secondary education showned that learners were not being sufficiently prepared to enter the workplace environment of self-directed teams.

One strategy toward sufficient preparation was cooperative learning. According to Johnson, Johnson, and Smith (2007), "Cooperative learning is one of the success stories of both psychology and education." Phillips (2000) emphasized that "Research supports a need for alternate methods of instruction. Research also supports the belief that cooperative learning increases achievement" (p. 5). Cooperative situations encouraged more frequent, effective, and accurate communication than did competitive and individualistic situations (Johnson, 1973, 1974). Within cooperative situations, communication was more open, effective, and accurate; in competitive situations, communication was closed, ineffective, and inaccurate (Johnson and Johnson, 1999). According to Slavin (1995), cooperative learning referred to a variety of teaching methods in which students worked in small groups to help one another learn academic

content. Cooperative learning involved much more than simply having students share or discuss material with other students, although this communication was important. The real crux of cooperative learning was that the group shared a goal, such as achieving a high group average on a quiz. Cooper (1990) felt that the three components of positive interdependence, individual accountability, and group processing were the critical features of the effective cooperative learning classroom. Johnson, Johnson, Holubec, and Roy (1990) believed the effectiveness of a group carrying out its goal was determined by the presence or absence of five essential elements of cooperative group learning. These elements were positive interdependence, individual accountability, collaborative skills, group processing, and face-to-face interaction. Johnson and Johnson at The University of Minnesota had a conceptual approach to cooperative learning that included these five basic elements. Jacobs, Power, and Inn (2002) listed several benefits that students received as a result of cooperative learning. Among those benefits were: improved academic performance; more active involvement in learning by students, regardless of past achievement level or individual learning needs; increased motivation to learn; increased student responsibility for their own learning; improved time on task; improved collaborative efforts; and improved student attitudes toward learning, school, peers, and self.

High school students, to be prepared for the future, must be prepared to exchange mathematical ideas effectively with others. Because interacting with others offered opportunities for exchanging and reflecting on ideas, communication was a necessary element of mathematics learning. Within the educational setting, cooperative learning techniques could be employed through self-directed teams. Self-directed strategies of

instruction were learner centered by providing the means and opportunities for learners to direct their own learning. Romig (1996) stated that neither schools nor corporations could simply verbalize the necessity for developing teamwork; both schools and corporations were required to actively use and promote teamwork to improve performance.

Statement of the Problem

According to Phillips (1995),

> One area in which cooperation is not a primary focus is in the classroom. Students are typically in competition with one another for good grades, teacher approval, and other rewards. As a result of this competition, students do not encourage, and may even discourage, one another's academic effort. (p. 4)

Minimal grouping existed in the mathematics classroom, and the group work that did exist did not exemplify teamwork or cooperative learning groups. Johnson and Johnson (1989) stated that not all groups were cooperative groups because placing people in the same room and calling them a cooperative group did not make them one. Having a number of people work together also did not make them a cooperative group. A traditional classroom group was a group whose members agreed to work together, but saw little benefit from doing so. In 1983, Johnson and Johnson found that the then-present school system offered few opportunities for students to interact socially in the classroom. Burns (1992) stated that social interaction was a necessary ingredient for learning to occur. She related social interaction to the number of opportunities children had to interact with their peers, parents, and teachers. Social interaction stimulated children to think through their viewpoints and to approach objectivity. Burns further stated that the communication of ideas in the classroom was important. When a student

was asked to remain quiet or silent in class, the teacher might have provided an environment that restricted learning rather than enhanced it. Mandel (2003) described an additional perspective by saying:

> Unfortunately, cooperative working skills are not included on standardized tests. In today's political climate, where the value and success of the educational process is directly linked to publishable test scores, cooperative work experiences are either de-emphasized or ignored. This creates a learning environment that is completely opposite to that which is required in the work world. (p. 89)

As Donato (2000) stated, teacher-to-student directives did not constitute true communication any more than student-to-teacher exchanges of brief, one-word answers, or patterned responses. Effective communication was identified in the results of empirical investigations (Johnson and Johnson, 1998; Slavin, 1995) which indicated that cooperative learning situations were positively perceived by students and were associated with many desirable affective outcomes, including the acquisition of improved communication skills and teamwork. Therefore, education should be expected to maximize the use of cooperatively structured learning situations.

Davidson (1990) listed some advantages as these situations were implemented into the mathematics classroom. Students were provided an opportunity to talk about mathematics instead of being passive listeners. Students were more likely to ask questions of peers than they were of teachers, and through questions and their contribution to the group discussion, they were more in charge of their own learning. In the traditional classroom structure, students had little opportunity to talk about their feelings; they rarely had an opportunity to express their excitement or frustration. They often felt alienated or isolated. Students working in small groups developed friendships, discussed mathematics, and talked about their feelings. Interaction about mathematics in

the classroom encouraged students to talk about mathematics outside of the classroom as well. They taught each other, which, as most teachers knew, enhanced understanding. In this way, they had the opportunity to clarify their areas of confusion. Their needs for affection, belonging, and recognition were no longer dependent on superior academic performance. The group developed a spirit of camaraderie. The members learned how to help each other learn. Teachers knew the good feeling that came from helping someone learn; students experienced that, too. Webb (1985) suggested that students who needed help and received explanations, as well as students who gave explanations, were required to engage in high-level cognitive restructuring in an attempt to make the material more comprehensible to their peers. A meta-analysis of 65 objective studies of peer instruction concluded that peer instruction was effective in producing positive academic and social outcomes (Kagan, 1994). Phillips' (1995) research found that

> [M]ost students reacted favorably to working in cooperative groups. Those who were uncomfortable at first seemed to improve each day as they worked with others. Some students found they understood some concepts better simply by hearing or seeing a different point of view. Students who felt they could sit back and let others do all the work found that they had to participate in order for their group to be successful. . . . (p. 19)

> There were several unexpected outcomes from the study of cooperative learning in the Geometry classroom. (1) Students thoroughly enjoyed the cooperative learning experience and discussed interest to see it used across the curriculum. (2) Administrative support was noted from a school district where there was usually minimal involvement. (3) Student individuality and individual needs became more apparent. (4) A few students did not do their share of the work at all times. (5) New friendships were formed. (p. 24)

> Several conclusions can be drawn. First, students' performance improved as a result of cooperative learning. The students in the experimental group exhibited improved individual math achievement and attitude toward Geometry, as well as a more positive attitude toward each other; these were apparent at the conclusion of the study. (p. 27)

Phillips' statements about cooperative learning led the reader to understand that specific problems could be addressed with its use.

Significance of the Study

Investigating cooperative learning and its relationship to teamwork and communication was important in mathematics education. The National Council for Teachers of Mathematics (NCTM, 2000) stated that greater opportunities should be provided for small-group work, individual explorations, peer instruction, and whole-class discussions in which the teacher served as a moderator. Instructional settings that encouraged investigation, cooperation, and communication also fostered problem-posing as well as problem-solving.

NCTM (2000) stated that, by learning to think and communicate effectively in mathematics, students would be better prepared for changes in the workplace that increasingly demanded teamwork, collaboration, and communication (Occupational Outlook, 2007). Cooperative learning provided for the continuation of classroom skills into the workplace. Kagan (1994) interpreted social skills as the ability to adjust one's behavior to work effectively with others and to communicate effectively with others; these can be learned and mastered by working and interacting with others. As a result, cooperative learning was a necessary component of curriculum intended to prepare students for the workplace. The reasons for group work in school were well established. Instructors expected students to learn how to manage themselves in teams, how to apply their behavioral science understandings to real situations, how to allocate tasks and monitor completion, and how to produce a whole product from the various pieces of

each person's contribution. These were valuable skills in the real world, where teamwork accounted for a vast number of projects in business (Riel, 1996). A prominent transportation company incorporated teamwork at every level of the business. Every employee, from entry level to CEO, experienced interviews that focused upon teamwork and group communication (V. Albanese, personal communication, January 24, 2002).

Although there was ample support for collaborative training of students using communication techniques, this researcher found that the existing data was lacking in student-to-student communication in the mathematics classroom. Available research involved deaf, autistic, special education, ESL, preschool students, multimedia, and teacher-to-student interactions. Research showed that students increased achievement and social skills when they were provided an environment where they could talk and take risks. Cooperative learning has shown to increase student outcomes such as teamwork and communication as a social skill.

Related Studies to Cooperative Learning

It was important to study achievement, social skills, different types of learning situations, and attitude in cooperative learning. However, it was also crucial for researchers and educators to understand the process of cooperative learning in the classroom, particularly the process of student interactions, in order to help in curriculum design and instructional planning. The studies on cooperative learning indicated that cooperative learning had a positive impact on achievement, many social skills, the ESL learner, web-based learners, and attitude. It was necessary to know not only the impact of this research on cooperative learning, but also for researchers to investigate the

interaction, the patterns of how and why cooperative learning helped students, and for educators to see the process as well as the outcomes. This study looked at how students interact.

The outcomes of cooperative learning methods have generally been quite favorable. Reviews of research presented by Sharan (1980), Slavin (1980, 1983), and Johnson and Johnson (1981, 1983) showed positive effects of cooperative learning in the following areas: academic achievement; self-esteem or self-confidence as a learner; inter-group relations, including cross-race and cross-cultural friendships; social acceptance of mainstreamed children; and ability to use social skills (if they were taught).

Cooperative learning promoted higher achievement than competitive and individualistic learning structures across all age levels, subject areas, and almost all tasks. This conclusion was based on a number of major literature reviews including those of Johnson and Johnson (1981), who conducted a meta-analysis on 122 achievement-related students, and Slavin (1983), who analyzed 46 controlled research studies that were conducted for an extended time in regular elementary and secondary classrooms.

Noddings (1985) noted that students shared similar language, and therefore they could translate difficult vocabulary and expressions and use language that fellow students could understand. Dees (1991) collected data that supported the use of cooperative learning with problem-solving. Valentino (1988) showed a reduction of math anxiety and increased attitudes toward math. Jones (1992) confirmed the increased course completion rate among students who used cooperative learning.

In order for cooperative groups to function, students needed to interact with each other. Data concerning what students said to each other while they learned cooperatively was limited. Students' verbal communication in cooperative learning groups fell into the following categories. First, students discussed the procedures by which they were to learn; second, students shared their knowledge and reasoning; third, students asked each other questions that encouraged oral rehearsal and rethinking of what they were learning; fourth, students confirmed each other's answers and reasoning when they were correct and disagreed when they were not; finally, students encouraged each other to work harder and be more responsible (Davidson, 1990). However, literature lacked descriptions of verbal communication among students. The question remained: what was actually being discussed in these cooperative groups? An important contribution to research in this area would encompass determining how students communicated and interacted in an authentic cooperative learning environment.

Purpose of the Study

When researching communication in cooperative learning groups, the teacher/researcher found it difficult to find studies on the actual verbal interaction among students. Understanding communication in the mathematics classroom required knowing what students said to one another. There was a lack of research looking at interaction patterns in cooperative learning content in the mathematics classroom so the purpose of this study was to address that issue. This descriptive qualitative study extended the current research that emphasized cooperative learning in the mathematics classroom. The purpose of this study was to describe discussions during cooperative

learning activities in a high school mathematics classroom. It focused on communication skills and teamwork issues.

Research Questions

NCTM (2000) stated that instructional settings should encourage cooperation and communication. According to Johnson and Johnson (1999), interpersonal skills may be the most important set of skills that contribute to students' employability. The research questions were developed from the pilot study and the literature reviewed in this study. Therefore, this study focused on the communication and teamwork skills demonstrated via journals, questionnaires, processing forms, and audiotaped discussions from high school mathematics classrooms in which cooperative learning activities were taking place. The research questions were originally as follows:

1. How frequently and/or to what extent does evidence of listening occur in a discussion in a high school mathematics classroom within a cooperative learning group?

2. How frequently and/or to what extent does evidence of trust-building occur in a discussion in a high school mathematics classroom within a cooperative learning group?

3. How frequently and/or to what extent does evidence of positive talk occur in a discussion in a high school mathematics classroom within a cooperative learning group?

4. How frequently and/or to what extent does evidence of role-playing occur in a discussion in a high school mathematics classroom within a cooperative learning group?

After conducting a pilot study, the researcher determined that positive talk and role-playing should be eliminated. Positive talk could not be objectively studied because of the acceptable level of sarcasm among classmates. Listening became the major factor and therefore role-playing was eliminated from this study.

As the study progressed, the researcher recognized that the study of listening became based upon the students' interactions. The student's interactions were recorded in the transcripts of the audiotapes. A case study approach was applied in this study. In particular, three Geometry classes in a high school setting were examined in detail. Details included in the study were student journal entries, transcripts, observation checklists, and teacher journal entries. The final research questions were:

1. What were the interaction patterns in a high school mathematics classroom within a cooperative learning group?

2. What were the student-learning experiences while participating in each of the three activities in a high school mathematics classroom within a cooperative learning group?

This study contributed to the body of research on cooperative learning. Cooperative learning proved beneficial for a wide variety of students: the academically gifted, the social outcast, those with special needs, and students who previously had very little in common with each other.

Summary

Traditional mathematics instruction seemed to ignore Glasser's (1986) statement that many students were motivated to come to school to be with their friends and that

they had a strong need to be accepted, to belong, and sometimes to influence others. Cooperative situations promoted more frequent, effective, and accurate communication than did competitive and individualistic situations (Johnson, 1973, 1974). Working in teams was found to promote more positive relationships and social support among members as well as greater social competencies (Johnson and Johnson, 1999).

Davidson (1990) noted that school discipline was often designed to prevent students from talking to one another in class. By setting up learning situations that fostered peer interactions, the teacher met a basic human need for affiliation and used the peer group as a constructive force to enhance academic learning. Active engagement in learning could be combined with peer interaction by letting students work together in small cooperative groups. The National Council of Teachers of Mathematics (2000) stated that, by learning to think and communicate effectively in mathematics, students would be better prepared for changes in the workplace. Workers were expected to change jobs at least four to five times in the next 25 years and each job would require retraining in communication skills.

Traditional mathematics instruction did not incorporate strategies to encourage teamwork or effective communication. The mathematics teacher's job was to increase students' interest in, knowledge of, and ability to apply math concepts. Additionally, teamwork and communication skills were a positive additional benefit of cooperative learning.

Definition of Terms

The following definitions were provided for reader clarity.

Cooperation. Working together to accomplish shared goals.

Cooperative learning. An instructional strategy in which students work together in small heterogeneous groups to help each other learn (Slavin, 1983).

Face-to-face interaction. The opportunity for students to promote each other's success by helping, assisting, supporting, encouraging, and praising each other's efforts to learn. Also included are verbal and nonverbal responses of other group members (Johnson and Johnson, 1999).

Facilitation of math learning. Providing an environment that encourages students to help each other while talking mathematically and sharing the desire to learn the concepts rather than just completing the assignments.

Group processing. Exists when group members discuss how well they are achieving their goals and maintaining effective working relationships. Groups needed to describe what member actions are helpful and unhelpful and make decisions about what behaviors to continue or change. Students must also be given the time and procedures for analyzing how well their learning groups are functioning and be able to set a goal for the next time (Johnson and Johnson, 1999).

Group regulation. A combination of peer coaching, questioning, keeping the group together, staying on task, involving all group members, and completing assignments.

Group reward. A reward which had been earned by the individual achievement of all members; examples include homework passes, pizza party, pencils, and candy.

Grouping. Refers to groups of students with differing abilities, ethnicity, and/or gender; formed to accomplish academic and social goals.

Individual accountability. When the performance of each individual student is assessed and the results given back to the group and the individual. Common ways to structure individual accountability include administering an individual test to each student, randomly selecting one student's product to represent the entire group, or having each student explain what has been learned to a classmate.

Interaction. Dictionary.com provided a variety of definitions for *interaction*; the first was "reciprocal action, effect, or influence." The teacher/researcher accepted that definition; to further define the student interactions recorded for this study, numerical standards were set.

Listening. A behavior that exhibits listening might look like: face focused on the talker, leaning toward the speaker, or appropriate nods of the head. A discussion that exhibits listening might sound like: asking for more details, "really," paraphrasing, or silence.

NCTM (National Council of Teachers of Mathematics). Professional organization that serves as a resource and guide for all who make decisions that affect the mathematics education of students in prekindergarten through Grade 12.

Numbered Heads. A cooperative learning structure used to ensure that all group members have mastered a concept. The steps are: students number off or are assigned a number between 1 and 4, teacher poses a question, students work out the problem individually, students put their heads together to make sure everyone agrees on the answer, and the teacher uses a spinner which signifies which group and which member must answer (Kagan, 1994).

Positive interdependence. The perception that a group member is linked with others in a way so that he cannot succeed unless they do (and vice versa); their work benefits you and your work benefits them. It promotes a situation in which individuals work together in small groups to maximize the learning of all members, sharing their resources, providing mutual support, and celebrating their joint success. Positive interdependence is achieved by establishing mutual goals, joint rewards, and divided resources (Johnson and Johnson, 1999).

Role-playing. Playing different self-assigned roles within the group and having the ability to change roles in different groups and different situations. Looking for equal contribution, not one member doing all of the work or a free loader letting everyone else do all of the work. Other examples include the leader or the independent. A behavior that exhibits role-playing might look like: pointing to the directions, pointing to the clock, time-out signal, nod of head, calm-down gesture, high five, taking turns, raising hands, or showing paper. A discussion that exhibits role-playing might sound like: "Do you agree?" "I want to hear from you now," "Your turn," "Let's go around once," "Time out," "Can you add to that?", "Don't forget we have five minutes left," "Let's move on and come back to that later," "Let's make a plan," "Let's get started," or "Any other suggestions?"

Roles. Teacher-appointed cooperative learning roles to help members differentiate their rights and responsibilities, to help define expectations and behaviors for self and others, and, optimally, to help groups communicate and accomplish their tasks (Baloche, 1998). Examples are runner, encourager, task master, and quiet keeper.

Social skills. The ability to adjust one's behavior to work effectively with others and to communicate with others. These skills can be learned only in the process of working and interacting with others (Kagan, 1994). Cooperative skills include leadership, decision-making, trust-building, communication/listening, and conflict-management. Groups can not function effectively if students do not have and use the needed social skills (Johnson and Johnson, 1999). Skills that help students get into groups, help groups stay together and complete the job, help students build an understanding of academic material, and encourage students to become empowered thinkers (Baloche, 1998).

STAD (Student Teams Achievement Division). A cooperative learning structure used to master basic facts. Students take tests individually; however, group members are responsible for ensuring that all members understood the material to be tested. Bonus points are earned depending on the improvement scores of group members (Slavin, 1995).

Team. People who worked well in teams would: listen to others' suggestions, trust the group's decisions, learn from other people, not believe they have all the answers, play different roles in teams at various times, and encourage others to speak up (Maduschke and Grummon, 1996).

Teamwork. The degree to which the students feel comfortable working in teams; attention is given to the self-directed goal of the group.

Teamwork skills. Influences how effective an individual member is as part of a team and includes: adaptability, coordination of team activities to complete a task on

time, decision-making, interpersonal skills, leadership skills, and communication (O'Neil, 1998).

Traditional instruction. Sequential, didactic instruction that uses the lecture method as its principal delivery system. The instructor is seen as the deliverer of knowledge and the students are the receivers of information.

Trust-building. A goal which is achieved when students accept and support each other, are willing to share ideas, are interested in each others' responses, and can reach consensus.

Uncommon commonalities (Placemat). A cooperative learning structure used for team-building that allows group members to become familiar with each other. Students try to find commonalities among group members that separate their group from other groups. Using the uncommon (to other groups) commonalities (to members of their group), the group produces a group name (Kagan, 1994).

CHAPTER II

REVIEW OF LITERATURE

Introduction

A math teacher's job is primarily threefold. The teacher is expected to increase the students' interest in mathematics, knowledge of mathematics, and ability to apply math concepts. Cooperative learning is one method of achieving these goals. Further benefits of cooperative learning are its positive effect on teamwork, cooperation, communication, and listening in the mathematics classroom. Therefore this chapter addressed these concepts in detail to support the base of research. Was cooperative learning an effective educational tool? This study was initiated as a result of the researcher's interest in and use of cooperative learning in a high school mathematics classroom. The researcher encourages all teachers to employ cooperative learning strategies within all levels of educational curriculum. Teachers should record strategies, methodologies, and verifiable conclusions, in addition to the personal reactions of the students who participated, their parents, and everyone involved or affected by the use of cooperative learning. Further study, whether formal or informal, would provide bases for study by others. This researcher contends that cooperative learning was beneficial for all students and, therefore, should be utilized as an effective teaching strategy.

People were brought together to complete projects because, as a popular adage says, "Two heads are better than one." By joining their individual forces of intelligence

and experience, people were expected to complete a project more efficiently and more effectively. However, when people were brought together for such a purpose, the human element often was overlooked while the project became the focus (Hulse-Killacky, Killacky and Donigian, 2001).

The American Society for Training and Development, with the assistance of the U.S. Department of Labor, surveyed Fortune 500 firms to determine specific skills that were desired by employers. The top five skills, in priority order, were teamwork, problem-solving, interpersonal skills, oral communication, and listening (Baloche, 1998). Numerous topics were discussed to serve as a framework for building an understanding for the research undertaken in this study. Teamwork, cooperation, communication, and listening were needed in the classroom and in the workplace even though teamwork and communication were typically lacking in the classroom. The specifics of cooperative learning and teamwork were addressed and related studies were documented.

Teamwork and Cooperation were Needed in the Classroom

A basic arena in the disciplined use of cooperative learning was teaching group members the small group and interpersonal skills each needed to work effectively with the others. In every group, members were expected to work to achieve the goal and also learn the interpersonal and small group skills each needed in order to function as part of a group. If members did not learn teamwork skills, they could not have completed the task work. If group members were inept at teamwork, their task work would tend to be substandard. On the other hand, the greater the members' teamwork skills, the higher

would be the quality and quantity of their learning. Cooperative efforts were inherently more complex than competitive or individualistic efforts because individuals must be simultaneously engaged in task work and teamwork. In order to coordinate efforts to achieve mutual goals, individuals must know and trust each other, communicate accurately and unambiguously, accept and support each other, and resolve conflicts constructively (Johnson, 1993, 2003; Johnson and Johnson, 1994).

For individuals to learn and adopt the necessary skills and strategies, they must be educated in instructional settings that encourage investigation, cooperation, and communication, in addition to fostering problem-posing as well as problem-solving. In addition, all students could profit from discussions of specific problem-posing techniques (NCTM, 2000). The idea that a school class could become a cooperative learning community rather than a competitive aggregation of separate individuals was gaining wider acceptance at every level, from preschool to graduate school (Clark, 2001). Mandel (2003) stated:

> Cooperative learning has been shown to be extremely effective in teaching students higher-level skills. This is especially true when one wants students to think divergently, work together to generate and test hypotheses, reason casually, master complex bodies of information, and analyze social situations, and to develop flexible social skills—all crucial abilities for success in today's business climate. (p. 27)

The primary focus in improving group behavior was the ability of the teaching staff to direct student groups. There was little discussion of explicit training in team skills for the students; yet without these skills, the students' effectiveness in group work was reduced (Blair, 2004).

Brown (2000) reviewed available resources on classroom groups and found the following drawbacks. They seemed to lack enough specificity to guide instructors who have teaching content as their primary concern. They did not provide enough rationale for suggested practices. They did not give enough direction for structuring the experience to prevent some common problems. Finally, they did not provide strategies to address problems that did occur.

Academic goals ranked high on the priority list of high school mathematics teachers. Social goals and academic goals might have been accomplished simultaneously. Numerous social goals were achieved in a cooperative setting. Working as part of a cooperative team enabled an individual to make friends and avoid isolation. High school students valued making friends and being responsible to others, often even more than the pursuit of academic goals (Blair, 2004).

University students were increasingly being asked by faculty to work cooperatively. This increased focus on interaction was partly a reaction to societal changes that included a new emphasis on teamwork in the business environment in addition to an understanding that communication skills were increasingly necessary.

As group cohesiveness increased, the following seven categories were noticed: (a) absenteeism decreased, (b) student commitment to group goals increased, (c) feelings of personal responsibility to the group increased, (d) willingness to take on difficult tasks increased, (e) motivation and persistence in working toward goal achievement increased satisfaction and morale, (f) willingness to listen to and be influenced by colleagues increased, and (g) productivity increased.

Small group learning offered opportunities for each student to become an active participant. Each student had a variety of skills to bring to group work. Rogers, Reynolds, Davidson, and Thomas (2001) noted the following student characteristics that would have been addressed by group work. The effective instructor must be aware of how each group was functioning and must also support each student's active participation. One student might perform basic computations quickly; another student might easily understand a new idea. One student might be comfortable with a calculator or computer while another excelled at reading. One student who struggled to get started could often complete a problem once he began; another student might have no trouble completing the first step. The student who was quick and usually accurate might struggle to verify his own work; but the slower student who questioned the process might help to find errors in the quick solution. When a cooperative learning group functioned correctly, students learned to identify and integrate their varied skills.

Students who have not had previous instruction in team skills can not be expected to demonstrate those skills that are required for effective teamwork. Students would be faced with a situation in which the skills they were expected to employ were not inherent but must be learned. Instead, when students learned the basic approaches and techniques of teamwork, that positive experience provided a basis for both practice and improvement of those same skills (Blair, 2004).

One of the main reasons for a group's success was the friendly atmosphere where each person felt safe. This was particularly important at the early stages of a task when the group must generate ideas; they had to feel able to express ideas without fear of

personal criticism. The students knew and felt comfortable with each other throughout the process (Blair, 2004).

Communication was Needed in the Classroom

All students needed extensive experience listening to, reading about, writing about, speaking about, reflecting on, and demonstrating mathematical ideas. Active student participation in learning through individual and small-group explorations provided multiple opportunities for discussion, questioning, listening, and summarizing. Using such techniques, teachers would be able to direct instruction away from a focus on the recall of terminology and routine manipulation of symbols and procedures toward a deeper conceptual understanding of mathematics. It was not enough for students to write the answer to an exercise or even to show all the steps. It was equally important that students be able to describe how they reached an answer or the difficulties they encountered while trying to solve a problem (NCTM, 2000).

The National Council of Teachers of Mathematics (2000) suggested the use of small groups in addition to other instructional methods in mathematics classrooms to help attain the major curriculum standards that focus on problem-solving, reasoning, communication, and making mathematical connections (Rogers, Reynolds, Davidson, and Thomas, 2001).

The Curriculum Standards demanded a context in which students were actively engaged in developing mathematical knowledge by exploring, discussing, describing, and demonstrating. Integral to this social process was communication. Ideas were discussed, discoveries shared, conjectures confirmed, and knowledge acquired through

talking, writing, speaking, listening, and reading. The very act of communication clarified thinking and forced students to engage in mathematics. Students' ability to understand the written and oral communication of others was an important component of instruction and assessment.

Communication was an essential element of mathematics and mathematics education. It was a method of sharing ideas and clarifying understanding. Through communication, ideas became objects of reflection, refinement, discussion, and amendment. The communication process also helped build meaning and permanence for ideas and made them public. When students were challenged to think and reason about mathematics and to communicate the results of their thinking to others orally or in writing, they learned to be clear and convincing. Listening to others' explanations gave students opportunities to develop their own understandings. Conversations in which mathematical ideas were explored from multiple perspectives helped the participants sharpen their thinking and make connections. Students who were involved in discussions in which they justified solutions—especially in the face of disagreement—would gain better mathematical understanding as they worked to convince their peers about differing points of view (Inagaki, Morita, and Hatano, 1999). Such activity also helped students develop a language for expressing mathematical ideas and an appreciation of the need for precision in that language (NCTM, 2000). In an online forum, Kagan (2009) stated that students were required to verbalize their thinking in accordance with national math standards. The purpose for this was three-fold: the students could be meta-cognitive; the students could be more aware of their thinking

processes through their own problem-solving; and, finally, the students had an opportunity to self-correct.

High school teachers could help students use oral communication to learn and to share mathematics by creating a climate in which all students felt safe in venturing comments, conjectures, and explanations (NCTM, 2000). Communication skills were learned. Given these realities, improving communication skills should have been one of education's highest priorities (Kagan, 1994). Students would read, write, and discuss mathematics; and they would conjecture, test, and build arguments about a conjecture's validity (NCTM, 2000). Instruction would be varied and include opportunities for appropriate project work, group and individual assignments, discussion between teacher and students and among students (NCTM, 2000). Greater opportunities would be provided for small-group work, individual explorations, peer instruction, and in-class discussions in which the teacher served as moderator (NCTM, 2000). When students talked with each other, the teacher had an opportunity to both monitor and, if necessary, adjust the students' thought processes. As students spoke among themselves, the teacher, by listening, could more authentically assess the class. This should occur because, since everyone talked, the teacher could assess the levels of understanding among all students, from those who never or rarely verbalized through those who regularly verbalized. In addition, as students verbalized, they learned, and learned to use correctly, the necessary academic language (Kagan, 2009).

A main objective in instructional settings was to establish awareness of team skills. To maintain that awareness, students must be allowed to practice these skills and given the time to reflect upon them as well as their own performance (Blair, 2004).

Leadership, presentation, problem-solving, communication, delegation and organization were a few of the social skills which were further developed through interaction (Cheng and Warren, 2000).

Effective communication could be further developed in classrooms. Effective group members would seek to listen so that they not only heard content from the speaker, but also understood the deeper meaning. The effective group member appreciated the value of others. He showed his appreciation by showing interest while listening and responding directly. Group members were likely to begin with differing levels of communication skills, but these skills would be invaluable in both group and work situations (Brown, 2000). According to Kagan (2009), people recalled significantly more of what they had said than what they had heard. Information gained through listening could have been maintained in short-term memory before being lost; talking, however, included the formulation of ideas that used different elements of the brain and thus led to the use of long-term memory.

Rogers, Reynolds, Davidson, and Thomas (2001) listed three reasons for using small groups in mathematics classes. Small groups offered a social support mechanism for the learning of mathematics. Students in small groups helped one another master basic information and procedures in the context of more meaningful problems. Finally, small-group learning offered opportunities for all students to succeed in mathematics. Kagan (2009) stated that student-student communication occurred in small groups; this format allowed students to interpret concepts in student-friendly language, thereby benefiting students who did not understand the teacher's explanation. Students tended to remain on task as they talked, rather than succumbing to the daydreaming that was more

likely to happen during quiet time periods. Finally, Kagan believed that students clarified their own thinking as they talked.

Learning can be expected to take place in a social arena; mathematics was filled with numerous topics for discussion. Students learned by listening, talking, explaining, and thinking with others. Students were often able to explain ideas to one another using a more informal language that was easily understood by their peers. In order to explain an idea, the student might often reach for a deeper understanding of that idea. As students worked in groups, they began to recognize the need for more precise language to express their ideas. Once they had achieved deeper understanding and clarity, students were ready to adopt the more formal language of mathematics that was used by their instructors and the authors of their textbooks (Rogers, Reynolds, Davidson, and Thomas, 2001).

Even those students who were hesitant to ask the instructor questions felt free to ask those questions of their peers in small groups. Mathematics problems were well suited for group discussion because they had solutions that were logical. Students were more likely to see different approaches to a solution when they were working with peers than when they were following the procedures of their instructor. Students who worked together might have solved a problem using several different approaches. By doing this, the solution would be verified and the students learned that there were several correct ways to approach the problem (Rogers, Reynolds, Davidson, and Thomas, 2001). Jacobs, Power, and Inn (2002) stated, "Cooperation as a value means encouraging students to see mutual assistance as a goal to strive for, to view others as potential

collaborators, and to choose cooperation as often as possible as a viable alternative to competition and individual work" (p. 67).

We are moving into a rapidly changing information-based, high-technology, and interdependent economy at an accelerating rate. Along with the traditional role of providing students with basic skills and information, schools must produce students capable of high-level thinking skills, communication skills, and social skills (Kagan, 1994). Learning that was structured cooperatively tended to increase achievement for all students (Baloche, 1998). As Kagan (1994) stated, success in life was more a function of one set of skills than any other: communication skills.

Cooperative Learning

Robert Slavin (1995) defined cooperative learning as a set of instructional methods in which students were encouraged or required to work together on academic tasks. Cooperative learning was distinguished from peer tutoring in that all students learned the same material, that there was not a tutor or tutee, and that information usually came initially from a teacher rather than a student.

Some contended that cooperative learning motivated students to do their best individually, as well as motivated students to help one another learn. This occurred for the following reasons. Students often translated the teacher's language into student language for one another (Dansereau, 1988). Students explained to others and also learned by doing so. Students who organized their thoughts and explained ideas to fellow group members utilized cognitive elaboration that greatly enhanced their own

understanding (Dansereau, 1988). Students provided individual attention and assistance to one another (Slavin, 1988).

Cooperative learning structures, as this study defined them, were much more than students working around a common table, helping, discussing, and sharing materials. Its foundation lay in assigning a group goal and rewarding the group, based on the group product (Dishon, O'Leary, and Wilson, 1984).

Cohen (1994) defined cooperative learning as students working together in a group small enough that everyone could participate on a collective task that had been clearly assigned, without direct and/or immediate supervision by the teacher. In order to provide a complete understanding of the instruction strategy known as cooperative learning, several descriptions were offered here. According to Slavin (1995), cooperative learning referred to a variety of teaching methods in which students worked in small groups to help one another learn academic content. As stated in Chapter I, Cooper (1990) felt that the three components of positive interdependence, individual accountability, and group processing were the critical features of the effective cooperative learning classroom. Johnson, Johnson, and Holubec (1990) believed the effectiveness of a group carrying out its goal was determined by the presence or absence of five essential elements of cooperative group learning. These elements included positive interdependence, individual accountability, collaborative skills, group processing, and face-to-face interaction. In cooperative classrooms, students were expected to help each other, to discuss and disagree with each other, to assess each other's current knowledge and to fill in gaps in each others' understanding. Cooperative work rarely replaced teacher instruction; rather, it replaced individual seatwork,

individual study, and individual drill. When properly organized, students in cooperative groups worked with each other to make certain that everyone in the group had mastered the concepts being taught. Michaelsen, Knight, and Fink (2004) declared,

> The special characteristics of teams are given. Groups and teams both consist of two or more people who interact in some common activity. What distinguishes teams from groups is that teams are characterized by: a high level of individual commitment to the welfare of the group; and a high level of trust among the members of the group. The process of having a group of people become a team requires: time interacting together; resources (especially intellectual); a challenging task that becomes a common goal; and frequent feedback on individual and group performance. When this happens, teams become capable of: inspiring a very high level of individual effort; a willingness to challenge each other without fear of giving offense because of a high tolerance for honest communication; working together very effectively; and successfully accomplishing very complex and challenging tasks. (p. 33)

Johnson and Johnson (1994) described cooperation as working together to accomplish shared goals. In cooperative learning situations there was a positive interdependence among students' goal attainment; students perceived that they could reach their learning goals if and only if the other students in the learning group also reached their goals. Within cooperative efforts, individuals sought outcomes that were beneficial to themselves and beneficial to all other group members.

Johnson and Johnson (1997) equated ideal learning in the classroom with the following characteristics: (a) a clearly defined goal, (b) cooperative structure, (c) shared responsibilities, (d) communication among members and between members and an instructor, (e) use of consensus for decision-making, (f) cohesiveness, (g) a sense of trust among members, (h) expectations of individual responsibility and accountability, and (i) members with strong interpersonal skills.

Together with Smith, Johnson, and Johnson (1991) described the type of group work that did not qualify as cooperative learning: having students who sat side by side at the same table and talked with each other as they did their individual assignments, having students who did a task individually with instruction that those who finished first were to help the slower students, and having students complete a report, with one student having done all the work and others merely putting their names on it. This study ensured that the students sitting and working in groups were indeed participating in cooperative learning. Each activity in this study contained a strong element of positive interdependence, individual accountability, and use of social skills; those were three key elements of cooperative learning. The group members had to share materials; each member initialed one final project to show agreement; each member was expected to be prepared to respond on behalf of the whole group; and each group put pieces together to complete a group proof. The students were held accountable for individual work as demonstrated by different colors, completing a worksheet, and taking a test. Each group filled out individual and group processing forms in which they could analyze and improve their social skills.

Slavin (1995) had identified three concepts he believed were essential to the success of a cooperative classroom: team rewards (the team earns a bonus if all members had quiz scores above a set criterion), individual accountability, and equal opportunity for success (each student contributed to the group by improving his/her past performance; therefore, all levels of students were equally challenged to do their best).

In cooperative learning, group interdependence replaced reliance on the teacher. Class activities were structured in a way that each group member's contribution was

necessary for successful completion of the assigned task. Students thus developed the feeling that they were responsible for and accountable to the group as well as to themselves for doing their best (Manera & Glockhamer, 1989).

In the process of working on problems with other students, learners gained several benefits. Often, a student who had one way of seeing a problem could profit from another student's view, which may have revealed a different aspect of the problem (Krutetski, 1976).

Well-structured learning goals that were designed to emphasize cooperation tended to promote higher achievement than learning goals that were designed to emphasize either individualism or competition. This was true in every subject, at all grade levels, and particularly when higher-thinking skills were required (Johnson, Maruyama, Johnson, Nelson, and Skon, 1981).

There were two types of groups to avoid when using cooperative learning. Pseudo learning groups were assigned to work together, but under the surface they were competing. The group members were rivals and they did not share their work. In this type of situation, students would work better individually. The other type of group to avoid was the traditional classroom learning group where students worked together but were evaluated and rewarded individually. They interacted mainly to clarify how assignments should be completed. Conscientious members felt exploited and put forth less than their usual effort and other group members tried to take advantage of the good intentions of others (Johnson and Johnson, 1994).

Johnson and Johnson (1994) offered some ideas to ensure successful cooperative learning in the classroom. They suggested that the teacher provide a clear task and a

group goal so that students knew they would *sink or swim* together. Next, they recommended that there be some element of individual and group accountability so that nobody could hitchhike on the work of others. The teacher would be expected to promote interaction where students explained to each other and discussed academic ideas. Students must be taught necessary interpersonal and small group skills. Finally, each group should be expected to discuss how well they achieved their goals and maintained effective working relationships.

Systematic and frequent use of cooperative learning group procedures had a profound positive impact upon the classroom climate; the classroom became a community of learners, actively working together in small groups to enhance each person's mathematical knowledge, proficiency, and enjoyment. Small groups provided a forum for asking questions, discussing ideas, making mistakes, learning to listen to others' ideas, offering constructive criticism, and summarizing discoveries in writing (Davidson, 1990).

Students' learning was supported when they had opportunities to describe their own ideas, hear others explain their thoughts, speculate, question, and explore various approaches. To provide for this, learning together in small groups gave students more opportunities to interact with concepts than do class discussions. Not only did students have the chance to speak more often, but they may also have been more comfortable taking the risks of testing their thinking during problem-solving situations in the setting of a small group. Often even the weaker student had some productive insights to offer, in addition to sharing information. The stronger students learned patience and better

ways to express themselves in order to make sure that each group member understood the solution (Davidson, 1990). Michaelsen, Knight, and Fink (2004) stated:

> The literature on small-group effectiveness identifies a number of group interaction characteristics that are clearly different in newly formed as compared to longer-term groups. These characteristics undoubtedly have implications for the kind of give-and-take discussion that is essential to group and team effectiveness, regardless of the setting. They include individual members' level of trust in, and attraction to, their group; motivation to achieve group goals; willingness to help each other; awareness of each other's skills and abilities; ability to share information effectively; willingness to disagree; preferred method for resolving conflict; overall ability to complete difficult intellectual tasks. (p. 24)

Advantages of cooperative learning were numerous. Students were provided an opportunity to talk about mathematics instead of being passive listeners. Students were more likely to ask questions of peers than they were of teachers, and through questions and their contribution to the group discussion, they could have more control of their own learning time. In a traditional classroom structure, students had little opportunity to talk about their feelings. They rarely got to express their excitement or frustration. They often felt alienated or isolated. Students working in small groups would develop friendships, discuss mathematics, and discuss their feelings. Interaction about mathematics in the classroom encouraged students to talk about mathematics outside of the classroom as well. They taught each other, which enhanced understanding. In this way they had the opportunity to clarify their individual areas of confusion. By working in small groups, the students developed friendships with their classmates and those friendships extended outside the classroom. Their needs for affection, belonging, and recognition were no longer dependent on superior academic performance. The group developed a spirit of camaraderie. They learned how to help each other learn. Teachers

already knew the positive feeling that comes from helping someone learn. Students could experience that, too (Davidson, 1990).

Nonassertive college students might find themselves facing highly dominant and even argumentative or aggressive teammates. Treating each other with mutual respect was the ideal speech situation. All members took responsibility for ensuring that respect through shared leadership. These two norms—respect and shared leadership—were so vital that their importance could not be overstated. The classroom was the place where individuals could learn from others; those who have been rewarded for dominance could learn to share control; those who have been rewarded for submissiveness can learn to lead. The qualities of the team as a unit could not be measured in the straightforward ways that were used for concrete events like team presentations. It was vital that groups learned to identify the behaviors that helped them succeed and those that stifled them (Hoover, 2002).

A small-group structure had the potential to maximize the active participation of each student and to reduce an individual's isolation. It provided a setting that valued social interaction, a necessary element of children's learning. When organized into small groups, more students had the opportunity to offer their ideas for reaction and to receive immediate feedback (Burns, 1992).

Small groups provided a social support mechanism for the learning of mathematics. Students had the opportunity to exchange ideas, to ask questions freely, to explain to one another, to clarify ideas and concepts, to help one another understand the ideas in a meaningful way, and to express feelings about their learning. This was part of the social dimension of learning mathematics. Small-group learning offered

opportunities for success for all students in mathematics as well as students in general. Students within groups were not competing against one another to solve problems. The group interaction was designed to help all members learn the concepts and problem-solving strategies. Mathematics problems could often be solved by several different approaches. Students in groups discussed the merits of different proposed solutions and perhaps learned several strategies for solving the same problem. The field of mathematics was filled with exciting and challenging ideas that merited discussion. One learns by talking, listening, explaining, and thinking with others, as well as by oneself (Davidson, 1990).

Cooperative learning was entering the mainstream of education practice for many reasons. One was the extraordinary research base supporting the use of cooperative learning to increase student achievement, as well as such other outcomes such as improved inter-group relations, acceptance of academically handicapped classmates, and increased self-esteem. Another reason was the growing realization that students must learn to think, to solve problems, and to integrate and apply knowledge and skills, and that cooperative learning was an excellent means to that end (Slavin, 1995). An additional advantage, as stated by Phillips (1995), was that "The program can be adjusted to meet the specific needs of the individual student, classroom, and teacher. As the activities are varied, all students were able to benefit from the program" (p. 23).

After reviewing math education, cooperative learning, and teamwork resources, three cooperative learning strategies were selected: (a) Placemat (a team-building exercise), (b) Numbered Heads (a skill-mastering exercise), and (c) STAD (a reward-based exercise). Placemat was chosen because it allowed for the building of student

camaraderie. Numbered Heads allowed for the development of positive interdependence among group members, and STAD promoted positive interdependence by giving group rewards. It was determined that the most appropriate cooperative learning techniques for high school math would be a combination of various components of the Learning Together model developed by Johnson and Johnson (1999), the Student Team-Achievement Divisions (STAD) model created by Slavin (1995), and various components introduced by Kagan (1994). This integrated cooperative learning approach utilized positive interdependence among group members, face-to-face interaction, individual accountability, social skills, and group processing from the Learning Together Model. Appropriate assignment of students to learning teams, class presentations by an instructor, heterogeneous teams of three to four members working together to help each other master the information, individually taken tests, and improvement points were utilized from the STAD model. Components of Placemat and Numbered Heads (Kagan, 1994) were used to improve group cohesiveness.

Teamwork

A team is a group of people brought together by a common project and shared performance objectives. The members have complimentary skills or knowledge and an interdependence that requires that they work together to accomplish their project's objective. Team members hold themselves mutually accountable for their results (Parker, McAdams, and Zielinski, 2000).

Communication also exists between the instructor and the group. The instructor is the facilitator, expert, and evaluator. The instructor is expected to provide clarification, answer questions, provide information, and assist as needed (Brown, 2000).

One of the most important things a student can learn is how to be an effective team member. This experience is realistic preparation for the world of work, where many tasks are conducted within teams. The ability to work cooperatively is highly regarded by supervisors and bosses (Brown, 2000).

In order to be effective team members, all of the participants must attend sessions, arrive on time, work on the team's task, and participate in decision-making. When team members exhibit these attitudes and behaviors, they will accomplish their goals and objectives (Brown, 2000).

Several key components make teamwork successful. Students on the team see different solutions to a problem as they use their differing points of view. This enables students to reconsider their own solutions from a different perspective. The resulting process stimulates higher cognitive skills. Small teams offer members the chance to benefit from the knowledge, skills, and experiences that are available from others on the team. Students are also given the opportunity to verbalize their thoughts as they interact in small teams. These verbalizations foster the idea that those who teach are the ones who learn the most. Giving and accepting explanations enhance the learning process. Cooperation intensifies the learning process because high school students are interested in interacting with their classmates (Davidson, 1992).

Teamwork and Cooperation were Needed on the Job

Traditional notions of basic mathematical competence have been outstripped by ever-higher expectations of the skills and knowledge of workers; new methods of production demand a technologically competent work force. Engineering graduates are advised in three of the nine keys to getting hired: to be a team player, to sharpen your communication skills, to join that uncommon but essential combination of independent thinkers and leaders who work well in a team setting. Employees must be prepared to understand the complexities and technologies of communication, to ask questions, to assimilate unfamiliar information, and to work cooperatively in teams (Sigelman and Rider, 2005).

Wideman (2002) stated, "The tools and techniques of project managers are sweeping the western world in order to remain competitive in a global market. The employees and leaders that work in project teams are the ones that count" (p. 4).

By learning to think and communicate effectively in mathematics, students will be better prepared for changes in the workplace that increasingly demand teamwork, collaboration, and communication. These skills are also needed increasingly by people who will pursue careers in mathematics or science (NCTM, 2000). Technologies Inc. said that because workers have traditionally learned as individuals, they have entered the workforce prepared only to work as individuals. However, from today's perspective, employees will be expected to work in teams, and therefore students need to improve their relationship skills—team building and team participation (Stinson and Milter, 1996).

In the wide spectrum of contemporary careers, the ability to work effectively with other personnel is essential and so is the ability to communicate and work with people from other professions to solve interdisciplinary problems. In the real world of work, the heart of most jobs, especially the higher-paying, more interesting jobs, is getting others to cooperate, leading others, coping with complex power and influence issues, and helping solve people's problems in working with each other (Johnson and Johnson, 1989).

Teamwork has become increasingly important to business, industry, commerce, finance, banking, health care, education, volunteer associations, and every other organizational firm in American society and around the globe (Hoover, 2002). At Federal Express, for instance, 1,000 clerical workers were organized into teams of 5 to 10 people and were given the training and authority to manage themselves. Ideas generated by one team's problem-solving saved the company $2.1 million during 1996 (V. Albanese, personal communication, January 24, 2002). Blair (2004) stated: "Small teams are increasingly becoming the fundamental unit of corporate organization and only those employees who possess team skills will be able to succeed in many industrial companies" (p. 2).

In industry, the use of small teams is seen as a tool leading to certain success. The ability to function effectively as part of a work team is an essential skill (Blair, 2004). At Levi Strauss & Company, the methods for making blue jeans have changed. Workers are no longer responsible for making just one part of a pair of blue jeans. They now sit together and, as a team, work on jeans from start to finish. When one part of the process slows down, the team determines a solution. Teams set their own work

schedules; compensation and incentives are tied to team goals. Since this approach has been implemented, quality has increased and injuries and absenteeism have decreased (*Levi's Lessons*, 1992).

Employers must provide education in teamwork, leadership, communication, problem-solving, and decision-making. In an environment that focuses on teamwork, each employee must be concerned with not only his teammate's right of space, but also with his right to choose, his right to his own opinion, and his right to make decisions (Hoover, 2002). NASA research (Interpersonal relations, 2004) declares, "Team success depends in large part upon its member's ability to interact with each other because of the array of different personalities involved. Team members may not be able to or even want to change their personality traits, but learning how to deal with others is an essential part of teamwork" (Interpersonal relations, 2004).

In 1996, a prominent transportation company began incorporating the idea of teamwork. The purpose of the team was to provide the idea of intimacy to the customer. A client would have a finite number of people to talk with and each would have similar knowledge of that client's situation. Teamwork is now involved in every aspect of this setting, beginning with the initial interview. This company is cited because it, like so many other companies, now believes in teamwork on the job. The initial job interview at this company is known as behavior or event interviewing. The focus is on critical team skills instead of past experience. A panel interview is conducted; the interview focuses on the potential employee's ability to take directions and the interviewee's demonstration of interpersonal skills. An interview question may sound like "Tell me about a time you were working on a problem with a group when you handled the

problem. What was your role?" One question frequently asked at all levels of employment is "Tell me about a time when you set aside your work to assist a co-worker. What was the situation? How did the two of you solve the problem or resolve the issue? How did you approach this person?" (V. Albanese, personal communication, April 18, 1996)

Prospective employees are then put into a team of 8-10 people and are given a scenario; this scenario does not pertain to the business of the company. One example scenario that is used at all levels of employment describes the events of a couple's evening out where many things went wrong. The prospective employee is asked what the people in the story could have done differently to handle certain situations. The idea behind the team interview is to gain insight into the following: identifying leaders, identifying those who are overbearing, identifying those who ask for input, identifying each individual's response and feedback techniques; identifying each individual's responses to other's feelings, identifying each individual's type/s of conversation, identifying each individual's communication skills, identifying each individual's willingness to take directions, identifying each individual's response when someone gives an answer with which the individual disagrees.

Another example of teamwork in this workplace is each employee has a base wage and further compensation based on individual goals and team goals. Everyone is expected to communicate for the greater cause of the company. Each team is expected to rely on feedback from coworkers and to give feedback to coworkers. Each team has more than one checker. The seating is arranged in a circle so every team member has easy access to every other team member for questions. When help is needed, every

member is expected to ask another team member. Teams are continually asked how to improve communication and the teaming environment, as well as what is needed to be a better team. Employees are released from job duties to participate in team development and team activities. Weekly, members of each team are asked about problems the team is having and possible solutions for those problems. This company has had great success using teamwork and continues to use it on a daily basis.

Small teams are increasingly becoming the fundamental unit of corporate organization and only those employees who possess team skills will be able to succeed in many industrial companies (Blair, 2004).

> Group members must have or be taught the interpersonal and small group skills needed for high quality cooperation, and must be motivated to use them to coordinate efforts to achieve mutual goals, participants must (a) get to know and trust each other, (b) communicate accurately and unambiguously, (c) accept and support each other, and (d) resolve conflicts constructively (Johnson, 2003, p. 940).

Are those team-oriented strategies relevant to the classroom? The idea that a classroom can become a cooperative learning community rather than a competitive collection of separate individuals is gaining wider acceptance at every level, from preschool to graduate school (Clark, 2001).

Communication was Needed on the Job

Changes in the workplace increasingly require teamwork, collaboration, and communication. Similarly, college-level mathematics courses are increasingly emphasizing the ability to convey ideas clearly, both orally and in writing. To be prepared for the future, high school students must be able to exchange mathematical ideas effectively with others. Both the listener and speaker have responsibilities when

communicating. The speaker must actively attempt to express ideas clearly and concisely while the listener must actively attempt to comprehend what has been said and ask for clarification if needed. Both participants must be sure that the ideas have been communicated correctly (Blair, 1991).

Many educators and leaders in organizational development believe that collaboration, cooperation, trust and mutual respect are necessary in our changing, fast-paced, and complex world. Others believe that, as people learn to cooperate and collaborate in small groups, they can become more effective citizens in other areas of life. The task of creating and maintaining collaborative environments is not easy and requires a foundation of effective, open, and honest communication. In task groups the content or product often obscures personal and interpersonal arenas. Yet a focus on process allows people to begin a journey toward genuine understanding, respect, and empathy for different world views, styles, and needs. Ultimately, these actions foster the development of a community of people who can work together. Therefore, leaders must attend to the relationships in the group with the same intensity and enthusiasm they give to the content (Hulse-Killacky, Killacky, and Donigian, 2001).

Many leaders in both education and organizational development believe that collaboration, cooperation, and mutual respect are needed in our complex, fast-paced, and changing world. Still others believe that as people learn to cooperate and collaborate in small groups, they can become more effective participants in all areas of life. What is important is people's preference for how they function and so may be grouped accordingly. The differences among normal, healthy people can be the source

of much difficulty in understanding and communication, attributes that are so important in project teamwork (Wideman, 2002).

Pollak, a noted industrial mathematician, stated that workers will change jobs at least four to five times during the next 25 years and each job will require retraining in communication skills. Those workers can practice making and interpreting oral and written statements so that they can communicate effectively while working with others and can convey the results of their work with clarity and self-confidence (NCTM, 2000).

Different group members have different responsibilities within the group. The quiet member needs to speak up and contribute. The group has the responsibility to encourage and develop that person, to include him in the discussion, and to provide positive feedback each time that happens. The dominant member needs to consider whether he is, in fact, that dominant person. The group has the responsibility to ask whether that dominant member might like to summarize briefly or ask for viewpoints from other members (Blair, 1991).

Students will learn to adapt to the changing needs of the workplace. By learning to think and communicate effectively in mathematics, students will be better prepared for changes in the workplace that increasingly demand teamwork, collaboration, and communication. These skills are also increasingly needed by people who will pursue careers in mathematics or science (NCTM, 2000). Mandel (2003) acknowledged,

> It is critical for teachers to ensure that their students are prepared for the challenges of the twenty-first century workplace. The emphasis on standardized testing results is not expected to diminish any time soon—especially with the tremendous emphasis on test results espoused by contemporary politicians. But it is the concept of cooperative work groups that address the basic educational need of the students as they prepare for their entrance into the work force. (p. 60)

Teamwork and Communication were Lacking in the Classroom

History has long endorsed the single leader model and still anticipates chaos in its absence. According to Roby (1988) of the Society for the Study of Social Problems, most of us have, through authoritarian, competitive schooling, been stifled of the awareness of our real leadership abilities. Historically, classrooms have been places where children were seen and not heard, while teachers were instructed to be good disciplinarians. The days of the quiet classrooms are slowly being transformed as school systems move toward cooperative or collaborative learning. Here children discover how to function in groups or teams, coaching each other in the mathematics classroom (Hoover, 2002). Communication of ideas in the classroom is important. When children are asked to be quiet in class, the environment may restrict learning rather than enhance it (Burns, 1992).

A review of the literature revealed considerable interest in cooperative learning methods, as evidenced by a large number of articles and books on the topic. There is a need for students to learn how to work effectively in groups, in addition to learning content. Increased emphasis on teamwork in many work settings is fueling the search for employees who have these skills and abilities. Yet many, if not most, classrooms still emphasize independent student work. Few classroom teachers teach students how to be effective group members or how to be group leaders while still concentrating on the mathematical task. Many students report that they hate working in groups and/or that they have not experienced working in a group. Some report that they prefer to work independently because it is too frustrating and time consuming to try to work as a team. Instructors who want to use classroom groups face considerable student resistance in

addition to their own lack of knowledge about groups (Brown, 2000). Mandel (2003) affirmed,

> Formal assessment of cooperative work groups is one of the greatest concerns of students and their parents, especially in secondary schools. Students are fearful that their marks might be adversely affected by circumstances beyond their control—such as their nonworking group partners. This is particularly the case when one is working with above-average achieving students. (p. 94)

How can active engagement in learning be combined with peer interaction? By letting students work together in small cooperative groups (Davidson, 1990). Jacobs, Power, and Inn (2002) stated:

> We have many ways to help students build strong teams. For instance, we should not object if groups spend a bit of time chitchatting. After all, this chitchat offers a way of creating a relaxed, trusting atmosphere in the group. Furthermore, a key reason for using heterogeneous groups is to allow students from diverse backgrounds to get to know each other as people, rather than as members of a particular ethnic group, and so forth. (p. 47)

During the past 50 years, cooperative learning has been the least-used goal structure in instructional situations. Competitive and individualistic efforts have dominated classrooms. Cooperative learning has been relatively ignored and underutilized by teachers even though it is by far the most important and powerful way to structure learning situations (Johnson and Johnson, 1989).

Competitive and individualistic learning should not be abandoned. Each goal structure has its place and when they are used appropriately, they form an integrated whole (Johnson and Johnson, 1989). When students work together in cooperative groups, they will often disagree and argue with each other. Using intellectual conflicts for instructional purposes is one of the most dynamic and involving, yet least-used, teaching strategies (Johnson and Johnson, 1989, 1992).

It is hard to imagine how students can obtain skills like adjusting behavior to work effectively with others if they are not allowed to work together. Unfortunately, at present, most schools still rely almost exclusively on competitive and individualistic classroom structures. The ethnographic research reveals that teachers do about 80% of the talking in most classrooms. Students are expected to passively orient to the teacher; they literally have little or no influence regarding what and how to study (Kagan, 1994).

Specific Related Studies

For 30 years, researchers have consistently concluded that cooperative learning benefits participants. The research, which has included a variety of academic environments, has also shown that participants benefit in situations beyond the typical classroom. The specific parameters of this study have not been employed in previous research. Therefore, this study is unique. Previous research has been conducted with reference to cooperative learning in ESL (English as a Second Language) and online classrooms. Two ESL references are *We Can Talk: Cooperative Learning in the Elementary ESL Classroom* by Kagan (1995) and *Creating Jigsaw Units for the ESL Classroom. How to Develop Instructional Units for Cooperative Group Learning in the Communicative Curriculum* by Coelho (1988). Two online references are *Teaching and Learning Activities in the Online Classroom: A Constructivist's Perspective* by Odin (2002) and *Interaction in the Online Classroom* by Bowman (2001). The articles specifically relate to communication; although mathematics is the goal of the classroom in this study, students are expected to communicate effectively during cooperative learning sessions.

Related Studies Dealing With Cooperative Learning

Just as social and academic goals appear to be closely linked, so is cooperative behavior associated positively with academic success (Gillies and Ashman, 2003). Educational research literature has reported hundreds of studies about cooperative learning, making cooperative learning one of the most widely investigated approaches. The effects of cooperative learning have been compared with other instructional methods such as the lecture method and individualized instruction (Johnson 1989; Sharan, 1990; Slavin, 1990). Research conducted in varying subject areas and various age groups of students has been studied; conclusions have generally shown positive effects favoring cooperative learning in these areas: achieving academic success, developing higher-order thinking, increasing self-esteem and self-confidence as learners, developing inter-group relations including friendships across racial and ethnic boundaries, accepting mainstreamed students labeled as handicapped or disabled, developing social skills, and increasing the ability to consider another person's viewpoint (Rogers, Reynolds, Davidson, and Thomas, 2001).

From early on, reviewers of the cooperative learning literature have concluded that cooperative learning has its greatest effects on student learning when groups are recognized or rewarded based on the individual learning of their members (Slavin, 1983). For example, methods of this type may present certificates based on the average of individual quiz scores of group members, where group members could not help each other on the quizzes. Alternatively, group members might be chosen at random to represent the group, and the whole group might be rewarded based on the selected member's performance. In contrast, methods lacking group goals give students only

individual grades or other individual feedback, and there is no group consequence for doing well as a group. Methods lacking individual accountability might reward groups for doing well, but the basis for this reward would be a single project, worksheet, quiz, or other product that could theoretically have been done by only one group member. The importance of group goals and individual accountability is in providing students with an incentive to help each other and to encourage each other to put forth maximum effort (Slavin, 1993). If students value performing well as a group, and the group can succeed only by ensuring that all group members have learned the material, then group members will be motivated to teach each other. Studies of behaviors within groups that relate most to achievement gains consistently show that students who give each other elaborate explanations (and, less consistently, those who receive such explanations) are the students who learn the most in cooperative learning. Giving or receiving answers without explanation generally reduces achievement (Webb, 1989, 1991). At least in theory, group goals and individual accountability should motivate students to engage in the behaviors that increase achievement and to avoid those that reduce it. If a group member wants her group to be successful, she must teach her teammates (and learn the material herself). If she simply tells her teammates the answers, they will fail the quiz that they must take individually. If she ignores a teammate who does not understand the material, the teammate will fail and the group will fail as well.

Among the most widely used cooperative learning methods are those developed and researched by Johnson and Johnson and their colleagues at The University of Minnesota. Their methods emphasize four elements: face-to-face interaction, positive interdependence, individual accountability, and interpersonal skills.

In 1981, Johnson, and Johnson compared the effectiveness of different goal structures which can be found in the classroom. These goal structures are known as *cooperative*: students working together to achieve a shared goal; *competitive*: students working against each other to accomplish a goal that only some will achieve; and *individualistic*: students working alone to attain goals, with their accomplishments unrelated to those of the other students. In their meta-analysis of 286 findings obtained from 12 studies, Johnson and Johnson found that students using the cooperative structure had higher achievement than those using the competitive or individualistic goal structures.

In 1983 Slavin reviewed 46 studies of cooperative learning involving elementary and secondary students. In 1991 Slavin again reviewed cooperative learning studies. He adjusted the time frame slightly, but the rest of the criteria remained constant for the 67 studies. In his 1995 textbook, Slavin reported the results of another evaluation involving 99 studies that met his selection standards. The included studies used a control group, lasted 2 weeks in 1983 and 4 weeks after that, used achievement instruments which fairly assessed learning, and controlled for teacher effect. Slavin found that an average of 63% of students had significantly higher achievement, 4% of the cooperative learning students had significantly lower achievement, and 34% did not show significant difference in achievement between cooperative and traditional learning situations. While Slavin acknowledged the success of cooperative learning, he also concluded that the effectiveness of cooperative learning in raising achievement depends on a number of factors in addition to the exact cooperative learning method used. Slavin's STAD more consistently led to higher achievement than did other methods. He also concluded that

the use of group rewards and individual accountability is necessary for cooperative learning to influence achievement positively. Supporting his contention that individual accountability is essential, Slavin reported that studies in which a group of students is asked to generate just a single report do not show the same achievement benefits as those in which students are responsible for individual reports following group discussion.

Sharan, Shachar, and Levine's (1999) study compared the academic achievement of pupils in five classrooms taught in small cooperative groups against that of pupils from five classes taught in the traditional whole-class approach from Grades 2 through 6. Special achievement tests were constructed with items requiring responses at low and high levels of cognitive functioning. Findings here supported the hypothesis that small-group learning can lead to more superior achievement in higher-order thinking than does traditional whole-class instruction. The findings also support the hypothesis that small-group and traditional learning will not differ in their effect on learning that requires thinking at the lower levels of Bloom's taxonomy (Sharan, Shachar, and Levine, 1999).

Related Studies Dealing With Social Skills

Cooperative learning has positive effects on students' attitudes and confidence. Webb (1991) analyzed research on cooperative learning in mathematics for indicators of effectiveness based upon student interactions. Webb concluded that the most effective small groups are those where students were free to talk about what they understand and don't understand, gave each other detailed responses on problems, and gave each other a chance to discuss. Jacobs, Power, and Inn (2002) declared,

> Interaction among students, whether spoken or written, builds competence. This interaction is missing in classrooms where students spend the majority of their

> time listening to the teacher or to the one student selected by the teacher. This is why simultaneous interaction is such an important cooperative learning principle (p. 58).

In order for cooperative groups to function, students must interact with each other. Many teachers wonder, therefore, what student behaviors they should be looking for when they monitor cooperative learning groups in math class. Johnson and Johnson (1983) gathered hundreds of hours' worth of data concerning what students say to each other while they learn cooperatively. These studies have included both elementary and secondary classrooms and have occurred in science, math, social studies, English, language arts, engineering, and physical education classes. Through these studies, combined with the work of other researchers, a great deal has been learned about the nature of interaction that takes place within cooperative learning groups and what differentiates effective from ineffective cooperative learning groups. The types of statements students make in cooperative learning groups generally fall into the following categories. First, students discuss the procedures by which they are to learn. Second, students share their knowledge and reasoning. They give their ideas, argue for their conclusions, and provide their factual knowledge for others' benefit. Third, students ask each other questions that encourage oral rehearsal and rethinking of what they are learning. Fourth, students confirm each other's answers and reasoning when they are correct and disagree when they are not. Finally, students encourage each other to work harder and be more responsible. Surprisingly, within well-structured cooperative learning groups, students rarely make negative comments to each other or discuss topics unrelated to their task (Davidson, 1990).

A number of studies have examined the impact of cooperative learning experiences on the mastery and use of social skills. Lew, Mesch, and Johnson (1986) found that socially isolated and withdrawn students learned more social skills and engaged in them more frequently within cooperative than within individualistic situations, especially when the group members were rewarded for doing so. Generally, cooperative situations promote more frequent, effective, and accurate communication than do competitive and individualistic situations (Johnson, 1973, 1974). Within cooperative situations, communication is more open, effective, and accurate, whereas in competitive situations, communication will be closed, ineffective, and inaccurate (Deutsch 1962; Deutsch and Kraus 1965; Johnson 1971, 1973, 1974).

Cooperative learning groups involve more encouraging interaction among students than do competitive or individualistic learning situations. Dozens of studies have demonstrated that when students are allowed to work together, they experience an increase in a variety of social skills; they become more able to solve problems which demand cooperation for solution, better able to take the role of the other, and are generally more cooperative on a variety of measures, such as willingness to help and reward others (Kagan, 1994).

Social skills are defined as the ability to adjust one's behavior to work effectively with others and to communicate with others; these can be learned only in the process of working and interacting with others (Kagan, 1994). Thus, cooperative learning becomes a necessary component of curriculum reform if students are to be prepared for the job world of the future. Johnson and Associates (1981) and Slavin (1983) have summarized

the research: Cooperative learning results in more positive social development and social relations among students at all grade levels.

Peer tutoring results in positive outcomes for both tutees and tutors. A meta-analysis of 65 objective studies of peer tutoring concluded that peer tutoring was effective in producing positive academic and social outcomes for both tutors and tutees (Kagan, 1994).

Not only does cooperative learning have a positive effect on achievement, but it has also been linked to other positive social or affective variable outcomes. One benefit is the increase in social skills of students who participate in group work (Slavin, 1991). George noted that during the adolescent years, the need to belong to a group is in conflict with the need to be recognized as an individual. Group work addresses these conflicts. Cooperative learning has also shown increased time on task, increased liking of the class, increased motivation to learn, and decreased dependence on the teacher (Good, Reys, Grouws, and Mulryan, 1990). Most studies on management and communication determine that a combination of task and maintenance successes is necessary to determine that a group has been effective (Hoover, 2002).

Related Studies Dealing With Teamwork

After interviewing personnel managers from both the corporate and public sectors, Hawkins and Fillion (1999) listed the skills needed for team effectiveness. The following small-group communication skills are arranged from most to least supportive: (a) listening effectively, (b) understanding their role and responsibilities, (c) being a contributing member, (d) asking clear questions, (e) communicating effectively with

people of different cultural and professional backgrounds, (f) receiving information and transmitting an accurate summary, and (g) giving a brief, clear, coherent, well-organized, and informative presentation (Hoover, 2002).

Since 1990, the Consortium for Alternative Reward Strategies, or CARS, has conducted major studies of incentives in the workplace. CARS, a nonprofit group funded by consortium members and research sponsors, helps organizations design and implement performance reward plans for all levels of employees. CARS studies conducted from 1989 to 1996 examined hundreds of incentive plans, relying largely on surveys of management-level employees to gather information on the plans' effects. These studies sought to answer a basic question: Do gains from incentives exceed payouts by a significant amount? The studies concluded that most of the plans did spend the time to determine the gains, finding a 200% gross return on payout. The second conclusion stated that as organizations gained more experience with the plans, the more important issue concerned creating a framework for employee involvement rather than the size of the payout (Parker, McAdams, and Zielinski, 2000).

Hundreds of studies on team effectiveness have been conducted. Recently, three meta-analyses summarized this research. Overall, working in teams resulted in higher individual productivity than did working competitively or individually. These results held true for verbal, mathematical, and procedural tasks. Working in teams was also found to promote more positive relationships and social support among members as well as greater psychological health, self-esteem, and social competencies (Johnson and Johnson, 1999).

American business leaders are increasingly turning to team-based management practices to maintain a competitive edge. In the early 1980s, approximately 5% of United States employers used work groups; this number rose to 20% by 1992. Predictions suggest that approximately 50% of the U.S. workers will be participating in work groups by the early part of the 21st century (Freeman, 1996).

Related Studies Dealing With Cooperative Learning in Mathematics

The positive results of cooperative learning also apply to learning mathematics (Davidson, 1992; Davidson and Kroll, 1991). Reviews by Davidson (1992, 1994), Webb (1985, 1989, 1991), and Cohen (1994) specifically address cooperative learning in mathematics. Davidson (1989) reviewed more than 70 studies in mathematics, comparing student achievement in cooperative learning versus whole-class traditional instruction. In more than 40% of these studies, students in the small groups significantly outscored students in the control groups on individual mathematical performance measures. In only two studies did the control students perform better, and both of these studies had design irregularities. This evidence might be reassuring to teachers who are concerned about the potential effects of cooperative learning methods on students' achievement in mathematics. Webb (1991) analyzed research in mathematics that linked task-related verbal interaction to learning in small groups. Webb also examined the effects of different compositions of groups. Cohen (1994) focused on conditions under which small groups are most productive and included research on the interaction in these small groups.

Students working in small groups have the potential for giving understandable, timely explanations. Because they are also solving the problem for the first time, they may understand better than their teacher what other students do not understand (Vedder, Boekaerts, and Seegers, 2005). Furthermore, because students share similar language, they can translate difficult vocabulary and expressions and use language that fellow students can understand (Noddings, 1985). Also, they can provide help immediately when a student has difficulty.

The effects of cooperative learning on mathematical skills were consistently positive when there was a combination of individual accountability and some form of team recognition for commendable team achievement. The effects of small-group learning were non-negative (that is, not significantly different from traditional instruction) if the teacher had no prior experience in small-group learning, was not aware of well-established methods, and did very little to foster group cooperation or interdependence (Davidson, 1990).

The NCTM Standards encourage the use of cooperative learning as one of the primary instructional strategies in the classroom (NCTM, 2000). The emphasis on this mode of instruction is also apparent in the reform math curricula that are being proposed for all grade levels.

In recent years, the use of cooperative learning in the mathematics classroom has been explored by many researchers. In General Math at the high school level, the use of cooperative learning was found to significantly improve students' achievement on a post-test when compared to a control group (Slavin and Karweit, 1985). This finding was confirmed by a study that compared the achievement of students involved in a

cooperative setting versus students who worked individually (Sherman and Thomas, 1986). When cooperative learning was studied at the Pre-Calculus level using a quasi-experimental design, the findings were very similar. Those students involved in the classroom where cooperative learning was employed scored significantly higher on chapter tests than did control group members (Whicker, Bol, and Nunnery, 1997).

Duren and Cherrington studied ninth grade General Math classes in which cooperative learning strategies were being used over the course of the entire year. Results supported the conclusion that cooperative learning positively affects students' achievement; those students who worked in teams scored significantly higher than the control groups on the same test. A separate study indicated that seventh- and eighth-grade Pre-Algebra students using cooperative techniques not only scored higher than the control group, but also retained the information for a longer period of time (Duren and Cherrington, 1992).

Summaries of research on cooperative learning in mathematics support its use as an effective instructional technique. Davidson (1985) and Webb (1985) have shown that, in at least 40% of the cases, students in cooperative learning situations demonstrated higher achievement, with the remainder of cases showing no significant differences in the level of achievement when comparing the use of cooperative learning to other instructional methods.

Dees (1991) gathered data in a college remedial math course to assess whether cooperative learning helped students increase their problem-solving abilities. The results showed significant differences in favor of cooperative learning and students using cooperative learning performed as well or better on every measure in the study.

Valentino (1988) conducted a study of achievement, anxiety, and attitude toward math in two College Algebra classes. Valentino compared two instructional techniques (small group versus lecture/discussion) with each class having a different teacher. The results were that the group instruction method produced significantly better results in the areas of successful completion of a math course, reduction of math anxiety, and increased positive attitudes toward math.

Jones (1992) studied the retention of college-level Algebra students in a community college using a cooperative learning model. A total of six classrooms were involved in this study. The percentage of students in the experimental classes who successfully completed the course was significantly different from those in the control classes. Although there is ample support for cooperative learning, this researcher has found that the existing data is lacking in student-to-student communication in the mathematics classroom. Available research involves deaf, autistic, special education, ESL, or preschool students, as well as multimedia or teacher-to-student interactions. Cooperative learning has been shown to increase student outcomes such as teamwork and communication as a social skill. While it is important to study the above-mentioned topics, it is crucial for researchers and educators to understand the process of cooperative learning, particularly the process of student-to-student interactions in order to help in curriculum design and instructional planning.

Related Studies Dealing With Discussions in the High School Mathematics Classroom

Researchers have been urged to study classrooms in which teachers are attempting to help students develop their own understanding through the social negotiation of meaning as they work together and communicate with each other and the teacher (Cobb, 1996). However, very little research has been done with regard to language use in mathematics classrooms at any level, especially high school. Very few researchers in mathematics education actually work as teachers in classrooms and then report on their attempts to work with diverse groups of children. Five exceptions are notable. In a 1996 study, developing thoughtful whole group discussions was the focus for Lampert in middle school and Ball in third grade (Lampert and Ball, 1998). Team teaching with the regular teacher and focusing on developing curricular alternatives and teaching methods to engage students in thinking more deeply about mathematics, Parker (1993) worked with fifth graders and Romagno (1994) worked in a ninth grade basic mathematics class. No long-term studies of high school classrooms have been published with the researcher as teacher, nor has any study besides Brenner's (1995) focused on the confusion that occurs between students and teacher and among students as they work in small groups on mathematics (Kysh, 1998).

To analyze and compare the ways the groups used communication, Kysh developed five criteria. First, talk while working included three subcategories: working alone (thinking out loud with no response from other group members), work display (demonstrating the speaker's thinking), and working together (questioning, repeating, and explaining). Second, questioning included asking a mathematical question,

checking a solution or answer, and asking for help either directly (How did you do that?) or indirectly (I don't get this.). Third, repeating included students' repetition of others' statements to verify them or to internalize them, to re-explain or to pass on an explanation, or as a way of questioning an explanation by repeating it with the inflection of a question. Fourth, explaining included giving a step-by-step explanation, giving an answer, pointing out an error, correcting an error, and defending one's reasoning. And fifth, miscellaneous included reading, irrelevant connectors (noise used to fill the silence), and inappropriate comments (Kysh, 1998).

Strong correlations between achievement and communication were identified. Many studies have demonstrated the positive effect of cooperative learning strategies on student achievement. Most of these investigations have been input-output experiments; as a result, researchers have had difficulty accounting for the effect. The most frequently proposed explanation is that learning improves in cooperative learning groups because students rehearse and reorganize the material to be learned while verbally communicating with each other. The absence of observational data linking communication to achievement has reduced the persuasiveness of this explanation. Ross and Raphael (1990) provided some of the observational evidence that had been missing and demonstrated that only certain kinds of communication occurring in cooperative groups affect student learning.

Summary

Changing one's teaching methods is difficult; practice is necessary for teachers to avoid doing what they have grown accustomed to, repeating methods they benefited

from as students, and simply enjoying what feels most natural (Rogers, Reynolds, Davidson, and Thomas, 2001). As American businesses continue to implement group and teamwork strategies for employees, American schools must prepare the future workforce for that environment. Mandel (2003) stated:

> In the business world, projects are rarely conducted or concluded within a couple of hours. On the contrary, a business cooperative work group may be in operation over a period of years, depending on the scale of the particular project. The ability to function successfully and efficiently within a long-term cooperative work situation is a critical skill for students to learn if they are to be active, successful participants in the twenty-first century American economy. (p. 102)

The high school mathematics classroom is conducive to that preparation; cooperative learning and its inherent benefits acclimate today's learners for the workplace that requires effective teamwork, personal communication that deals with both problem-finding and problem-solving, and team success. Studies from the early 1990s reflect the necessity for cooperative learning strategies and the success of those strategies in the classroom and in the affected work environments.

This study attempted to provide additional observational evidence by reporting the results of the following research questions:

1. What were the interaction patterns in a high school mathematics classroom within a cooperative learning group?

2. What were the student-learning experiences while participating in each activity in a high school mathematics classroom within a cooperative learning group?

CHAPTER III

METHODOLOGY

Introduction

This research was a descriptive case study that examined the interaction among students who worked in cooperative learning groups. Case study was the best format to use for this research because, according to Merriam (1998), "A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context rather than in a specific variable, and in discovery rather than confirmation" (p. 106). A multiple-case approach examined the interaction between two groups of students while they worked in cooperative learning groups. Although research showed the need, there was minimal focus on these interactions. The conceptual framework of cooperative learning and teamwork provided the starting point to identify components that might provide meaning for high school mathematics teachers. As a classroom teacher, I was interested in not only the achievement of my students, but also their social interaction. As part of a previous action research project, data were collected through various sources while the students worked in cooperative learning groups. Data for this study were collected from audiotapes, observation checklists, and student notebooks. There were four major steps in the data collection phase of this dissertation: (a) participants, (b) pilot study, (c) data

collection, and (d) data analysis. The participants section described the participants and the site of the study. The pilot study section detailed the phases of the pilot study. The pilot study was conducted with Algebra II students; this study was conducted with geometry students. The data collection section included a week-by-week description of all activities that transpired in the classroom. The data analysis section described the cross-case analysis used in this study. The entire phase of the data collection encompassed a 9-week grading period.

Research Setting

This study took place in a suburban high school of 822 students. The student body consisted of 46% female students and 54% male students. The school population was predominantly white (99%). The school district was composed of middle-class to upper-class professional families. The surrounding community was in such a rapidly growing area that a new high school was needed to accommodate the growth. Academics were emphasized at this suburban high school. Ninety-five percent of graduates continued to postsecondary education. The district boasted of its proficiency scores, advanced placement scores, and academic team outcomes. The school district met 22 of 22 indicators on the 2003 School Report Card (Ohio Department of Education, 2002) (see Appendix C).

I was both the classroom teacher and the researcher. I held a Bachelor's Degree in Mathematics and a Master's Degree in Curriculum and Instruction. I held a permanent teaching certificate for Grades 7 through 12 and had 20 years of teaching experience at the same high school in which the research took place. I was enthusiastic

to incorporate new strategies into my mathematics curriculum. Given the opportunity to be a supervising teacher for student teachers, I eagerly agreed, seeing this as one means to remain current on the new trends in mathematics education. I attended workshops that helped me incorporate technology into the classroom. I tried new strategies with my students to check for improvement in academics and social skills. During the 2002-2003 school year, I taught three geometry classes and it was in these classes that I collected data.

I created heterogeneous groups based on each student's grade/achievement of the previous quarter. The groups each consisted of three or four students. There were eleven groups in three geometry classes. Data were collected on all 11 groups, but two groups were randomly selected to serve as the cases. The gender and age of these two groups are displayed in Table 1. Approval was gained from the students, their parents, the school's principal, the school district's superintendent, and the Institutional Review Board from The University of Akron (see Appendix A).

Table 1. Gender and Grade of Study Participants

Group	RED	GREEN
Gender		
Male	2	1
Female	2	2
Grade		
9^{th}	1	1
10^{th}	3	2

Research Design

A qualitative case study provided the best research technique for analyzing the discussion patterns among groups of students in high school mathematics classes. Case study procedures included student notebooks, observers' checklists, and audiotapes; these provided triangulation. The purpose of this case study was description; the researcher attempted to describe a phenomenon using thick rich description. The researcher classified student communication segments with respect to the interaction patterns and the student learning experiences. This study used a multiple-case approach to examine the discussions of two groups of students while they worked in cooperative learning groups.

Qualitative Research

According to Merriam (1998), qualitative research was an intensive, holistic description and analysis of a single instance or social unit. Merriam (1998) also stated that qualitative research was an umbrella concept covering several forms of inquiry that helped us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible. When applied to social science, qualitative research involved observing subjects in their own environments, communicating with them in their own languages, and interacting with them on their terms while they remained in their own natural settings. As this research process developed, emergent themes were discovered. Because qualitative research focused on contextual meanings, the research process required a data collection instrument that was sensitive to underlying meaning when collecting and analyzing data. Qualitative research was the

chosen design for this study in order to analyze interaction patterns among groups of students in high school mathematics classes.

A qualitative researcher encompassed the following five characteristics: (a) the researcher was interested in understanding the meanings people have constructed from their experiences; (b) the researcher was the primary instrument for data collection and analysis; (c) the researcher conducted fieldwork which involved on-site observations to examine behavior in its natural setting; (d) the researcher primarily employed a research strategy which built abstractions, concepts, hypotheses, or theories rather than testing existing theory; and (e) the researcher recognized that qualitative research focused on process, meaning, and understanding; the product of a qualitative study was richly descriptive. Data in the form of participants' own words and direct citations from documents were likely to be included to support the findings of the study (Merriam, 1998).

The ideal design of a qualitative study was emergent, flexible, and responded to changing conditions as the study progressed. Qualitative research was often used because it allowed the researcher to adapt to unforeseen events and change direction in pursuit of meaning (Merriam, 1998).

Case Study Research

In qualitative research, sample size was determined by the number of cases that were needed to provide in-depth information (Gall, Borg, and Gall, 1996). According to Bromley (1984), case study researchers got as close to the subject of interest as they possibly could, by means of direct observation in natural settings or by their access to

subjective factors such as thoughts, feelings, and desires. Descriptive case studies in education presented a detailed account of the phenomenon under study. They were useful in presenting basic information about areas of education where research had been minimal. Such studies often formed a database for future comparison and theory building.

Lincoln and Guba (1981) listed five reasons to support the naturalistic form of research known as a case study: (a) the case study provided the thick description necessary for a context evaluation; (b) the case study was grounded in the data that emerged in the context of certain boundaries; (c) the case study was a portion of a real-life situation; (d) the case study simplified the range of data and provided the reader with essential focused information; (e) the case study communicated beyond information offered for consideration; it was a vehicle for reporting appropriate in-depth understanding of the area under investigation.

This study employed case study research because of its appropriateness in the analysis of student discussions in high school mathematics classes. As a result of audiotaping and observing students in their natural classroom settings, thick rich descriptive data resulted. Additional data were gathered from student notebooks. Emergent themes evolved and demonstrated the flexibility of case study research.

Multiple-Case Study Research

Yin (1994) recommended that additional cases be selected to provide replication and to add certainty to findings. By gathering evidence from multiple cases, the evidence was considered to be more compelling and provided a more thorough study

than that of a single case because such use increased the potential for generalizing beyond a single case (Merriam, 1998; Miles and Huberman, 1994; Yin, 1994). According to Miles and Huberman (1994), multiple-case studies strengthened the precision, the validity, and the stability of the findings.

A multiple-case study included two stages: within-case analysis and cross-case analysis. Within-case analysis occurred when each case was treated as a comprehensive independent case. The researcher gathered data to learn as much as possible about the pertinent contextual variables. Following the individual within-case analyses, cross-case analysis began. In order to construct abstractions across cases, a qualitative, inductive, multiple-case study was conducted. As this process continued, the researcher attempted to determine a general explanation that suited each of the individual cases while recognizing the variations among the details.

This study used multiple cases to analyze the discussions of two groups of high school mathematics students. The analysis was derived from transcripts of those discussions, observers' checklists, and students' notebooks. These sources combined to provide a rich source of data. The researcher analyzed the data in Chapters IV and V and completed a cross-case analysis in Chapter VI. The purpose was to deepen understanding of the classroom discussions rather than to enhance generalizability.

Data Analysis

Yin (1994) defined data analysis as examining, categorizing, tabulating, or combining evidence to address the initial research questions. Because no set guidelines or strategies defined the process, analyzing qualitative data was challenging. According

to Merriam (1998), the purpose of data analysis was to derive meaning from the data by consolidating, reducing, and interpreting what people have said in addition to what the researcher had seen and read. As data analysis proceeded, the researcher considered both concrete data and abstract concepts by using both inductive and deductive reasoning. Description and interpretation were additional elements in this complex process. The findings of this study resulted from the meanings or understandings or insights as determined by the researcher.

I compiled a comparative data analysis that contained three steps: (a) preliminary, (b) comparative, and (c) selective. The preliminary phase involved theme coding of the data collected and transcribed from the students' discussions. I was interested to see if there were any rough trends in the data.

The comparative phase verified my interpretations of the coding. I checked to see if the observation checklists and contents of the students' notebooks had the same patterns. This confirmed my interpretation of what the participants felt.

The selective phase involved transcript recoding, the observation checklists, and components of students' notebooks to show the trends and patterns that were consistent in the three areas of data collected.

Transcribing the Data

Eleven groups of students were audiotaped while working in cooperative learning groups. The audiotapes were transcribed verbatim by the Research Department of Kent State University. Of those 11 groups, two were selected at random as the basis

for this study. The observation checklists and pertinent pieces of the students' notebooks were also transcribed.

Unit of Analysis

Gall, Borg, and Gall (1996) stated that the researcher should break the text into meaningful segments; a segment or analysis unit was a section of the text that contained one item of information that was comprehensible even if read outside its context. One of the most critical steps of interpretational data analysis was the development of a set of categories that adequately encompassed and summarized the data.

The units of analysis for the transcripts were the phrases and prompt-response combinations given by the students in the two groups. These units of analysis resulted from the dynamics of the groups rather than from the individual students within each group. The researcher determined the extent of each unit by considering the group dynamics in each discussion. Interactions among students may have been limited to one question and response or may have included additional pertinent questions and responses.

Data Reduction and Coding

The purpose of data reduction was to draw and verify final conclusions by using analysis to sharpen, sort, focus, discard, and organize data (Miles and Huberman, 1994). The data reduction for this study was completed by the elimination of extraneous talk and the coding of the transcripts for the purposes of: (a) the classification of the level of interaction of the communication segments, and (b) the classification of the task level of the communication segment.

Extraneous talk consisted of qualifiers (such as *um* and *hmm*). The researcher eliminated extraneous talk in order to facilitate the coding of the students' discussions.

After the extraneous talk was eliminated and in order to facilitate analysis, the researcher coded communication segments into categories and identified communication segments. Each communication segment consisted of either a single prompt and response or a series of prompts and responses related to the same topic. Communication was exhibited through students' verbal responses to a single prompt as they asked for verification, clarification, elaboration, or as they made further inquiry. The researcher color coded the transcripts to distinguish communication segments.

Students' attitudes changed, according to a pre- and post-Math Attitude Questionnaire (Appendix R); those changes were also summarized. The following chart is an example of one used by the researcher to note students' attitude changes. The changes were verified through analysis of the transcripts and the contents of student notebooks.

Figure 1 presents a blank template of the attitude changes according to the pre- and post-Math Attitude Questionnaire.

	Agree	Unsure	Disagree
Prefer working independently Pre- Post-			
Like working in groups Pre- Post-			
Will enjoy cooperative learning Pre- Post-			
Enjoy helping others Pre- Post-			
Will let others help me Pre- Post-			
Will enjoy cooperative learning Pre- Post-			
Am a cooperative person Pre- Post-			

Figure 1. Blank template of attitude changes according to the pre- and post-Math Attitude Questionnaire

Validity and Reliability

Internal validity dealt with the question of how research findings matched reality. When a researcher presented a clear chain of evidence, the internal validity of the study was greater. That chain of evidence should have concisely linked the research questions, the raw data, and the findings. The principle underlying the chain of evidence was to

allow the reader to follow the development of the evidence, beginning with the initial research questions and extending to the final conclusions (Yin, 1994). The researcher had the responsibility of providing an audit trail. The audit trail documented the research process used in the case study. I kept all items used in data collection, including the transcripts of the classroom discussions, the observation checklists, and the students' notebooks. I also kept a daily journal that contained details on the specific aspects of the study. I maintained an audit trail for possible replication of the study. An investigator could have used basic strategies such as triangulation and long-term or repeated observation to enhance internal validity. Triangulation involved the use of multiple investigators, multiple sources of data, or multiple methods to confirm the emerging findings. In this study, triangulation was achieved through the use of multiple methods of data collection, consisting of students' notebooks, observers' checklists and transcripts from audiotapes. Multiple sources of data were used. Triangulation validated the truthfulness or trustworthiness of my interpretations.

External validity was concerned with the extent to which the findings of one study could be applied to other situations. Case studies should be designed to increase the probability that the findings will be generalizable. Merriam (1998) cites guidelines a researcher might have utilized to improve the generalizability of a case study. The researcher should provide a thorough description of the phenomenon and should have conducted a cross-case analysis. As researcher, I employed the stated guidelines.

Reliability referred to the extent to which research findings could be replicated. Qualitative researchers sought to describe and explain the world as those in the world experienced it. Lincoln and Guba (1985) suggested thinking about the dependability or

consistency of the results obtained from the data. Rather than demanding that outsiders got the same results, a researcher hoped outsiders would concur that, given the data collected, the results made sense. When this occurred, the data were consistent and dependable. The question was not whether findings would be duplicated, but whether the results were consistent with the data collected. Member checking was used when other educators read the interpretations and agreed with the findings. Investigators used several techniques to ensure that results were dependable: the investigator's position, triangulation, and an audit trail. The investigator should have explained the assumptions and theory behind the study, her position to the group being studied, and the methods of data collection. Triangulation strengthened reliability as well as internal validity. Other researchers could authenticate the findings of a study by following the audit trail of the original researcher. An audit trail described in detail how data were collected, how categories were derived, and how decisions were made through the inquiry. I employed three methods to ensure reliability: (a) information on the theories behind the study, (b) triangulation of data by using multiple sources consisting of students' notebooks, observers' checklists and audiotapes, and (c) an audit trail to allow other researchers to authenticate the findings of the study by following the trail of the original researcher.

All research was concerned with producing valid and reliable knowledge in an ethical manner. Being able to trust research results was especially important to professionals in education where practitioners intervened in people's lives. Ensuring validity and reliability in qualitative research involved conducting the investigation in an ethical manner. This researcher assured study participants of both anonymity and

confidentiality. This researcher recognized an additional responsibility to maintain high ethical standards because the study was conducted in her own classes

Pilot Study

I conducted a pilot study for three main reasons: (a) to test the physical environment of my classroom; (b) to develop and revise the observation protocol; and (c) to train the observers. The students in my three Algebra II classes participated in the pilot study.

Test the Physical Environment

I was concerned about the following physical aspects of the classroom: (a) How would the students be seated in each group? (b) Where would each group be placed? (c) Would I have enough tape recorders? (d) Could I find a way to use extension cords safely or would I need to use batteries? (e) Where would the observers sit so they were close enough to the group to observe without being obtrusive?

This portion of the pilot study ran for one week. Groups of students in my Algebra II classes were used for the pilot study. I tried different seating arrangements with groups of three or four students. I recorded the students' conversations. I used observers in the classroom when the students worked in their cooperative learning groups.

I drew several conclusions after the physical assessment portion of the pilot study. The placement and selection of the students' desks were keys to the successful use of the tape recorders. The desks were arranged so extension cords could be placed in minimal traffic areas. I decided that extension cords would be more reliable and less

costly than batteries. When the desks were placed together, they needed to create a flat surface so the recorders would be stable. The groups needed to see the board but be far enough away from other groups so their conversations would not interfere with the assignment. The groups also needed to be able to get to the board as needed for each activity. The observers needed to have clear view of the group or groups they were observing. Each observer was seated near the assigned group so ample room was needed for a chair and room for movement if needed. The extension cords were taped down for safety. Seven different tape recorders were needed and the tape recorders were checked for problems and repaired as needed.

Develop and Revise the Observation Checklist

The pilot study was also used to develop and revise the observation checklist. The observation checklist began as an open-ended first draft (Appendix G). In the second phase, draft 1 was revised into a checklist; this was identified as draft 2 (Appendix H). In the third phase, draft 2 was scaled down to a manageable number of items and organized style; this was identified as the Final Observation Checklist (Appendix J). I relied upon the expertise of high school teachers from the building for the revision of the observation checklist. The pilot study helped identify behaviors that were later incorporated into the final observation checklist. The original open-ended observation form (draft 1) was a grid that listed each student and each general topic. The general topics were communication, positive talk, role-playing, and trust-building. The observers recorded everything they were able to witness. The observers each watched one student for two minutes and recorded what they observed in relation to the four

topics; their attention was then directed to the next member of the group. This continued for the duration of the class. Each student was evaluated several times before the observation form was complete. The list was compared to a previously compiled list from my research on the behaviors typically seen in a cooperative learning setting and the skills T-charts completed by students (Appendix K).

When being introduced to cooperative learning, students discussed what a skill looked like and sounded like. These responses were placed on T-charts. Listening was an example of one of the skills. This final list of behaviors was then reorganized and transferred to become draft 2.

A second revision of the observation checklist was conducted in an Algebra II class where the students were working in cooperative learning groups. The open-ended form (draft 1) was revised into a checklist (draft 2). This portion of the pilot study was used to test the usability of the observation checklist. Two student teachers working at the high school were used in this phase of the pilot study. The observers simply placed a check in the appropriate space in the grid that described what they witnessed. The observers watched a student and recorded that student's behaviors; then the observer's attention was focused on a second student and that student's behaviors were recorded. This continued for the remainder of the class period. I found this phase of the pilot study extremely beneficial in refining the observation checklist to a manageable number of items and an organized style. Observers' comments that helped to reorganize the checklists were "too many choices" and "the whole sheet needs to be on one page." I tallied the results from this phase of the pilot study. I took each block in the checklist and totaled the number of times that were witnessed by an observer. After studying

these results, I eliminated and changed behaviors whenever needed. On the second draft, nodding and shaking head were both listed as positive listening behaviors. These two behaviors were condensed into one on the final observation checklist. Nodding off and sleeping were both eliminated from a negative aspect of listening because I did not believe this would ever occur since no one exhibited either in the first or second phase of the pilot study. The final observation checklist was on one page and was a shorter version of draft 2.

It was after reviewing this information that I eliminated positive talk from the observation checklist and from the study. I determined that because sarcasm was so widely used and accepted within the high school setting and in the cooperative learning groups, it was difficult to distinguish between a negative statement and a sarcastic one.

Train the Observers

The pilot study allowed for the time needed to train the observers. One problem with observation was that the observer, although unintentionally, may have changed the situation being observed. For example, the teacher and students were both likely to change their normal behavior patterns when an observer entered the classroom. Observers in this study visited the classroom several times before recording any observational data that would be used in this study. The purpose of these visits was to allow the students to become accustomed to being observed so they would behave normally when observational data were collected for this study. The observers were assigned to watch one or two groups of students. Each observer was seated near a group but hopefully not close enough to alter the group's discussion. The observers were in

the classroom to observe behaviors, not to listen to the group's conversations. Each observer watched one group member, recorded that individual's behaviors and then rotated to the next group member. This process continued for the duration of the class period.

The use of individuals not involved in the study allowed for control of observer bias that could have occurred when the same individual who designed and carried out the research study also did the observing. Researchers have found that the most reliable observers tend to be intelligent, verbally fluent, and motivated to do a good job (Gall, Borg, and Gall, 1996). The students in this study saw many observers of different levels of formality throughout the quarter. Observers in this study included the district superintendent, the high school principal, assistant principal, three guidance counselors, several teachers, and support staff such as the technology specialist and the pupil-relations specialist.

Each group of observers met with me to discuss the meaning of the items on the checklist and exactly what they would witness during their visit to the classroom. Any observer questions were addressed at this time. A reminder notice was sent to the observers to reiterate what would occur in the classroom and what was expected of them. Each observer and I discussed behaviors and the appropriate method of completing the checklist.

Observations took place in the natural field setting instead of a location designated for the purpose of interviewing; observational data represented a firsthand encounter with the phenomenon of interest. Critics of participant observation as a data-gathering technique pointed to the highly subjective and therefore unreliable nature of

human perception. However, Patton (1990) suggested that observers were planning ahead what they systematically observed, and they were trained in observational techniques. These factors differentiated everyday observation from research-related observation. An investigator might have wanted to gather data through observation for many reasons. As an outsider, an observer noticed things that had become routine to the participants themselves, things that may have led to understanding the context. Observations were also conducted to triangulate emerging findings. Observation made it possible to record behavior as it happened.

Data Collection

The use of multiple methods of data collection was a methodological strength of case studies (Merriam, 1998). This study focused on three methods of data collection. The purpose of the three methods was to focus on the naturally occurring events of the students in the cooperative learning groups. The three methods of data collection that provided a thick rich description of the events in the classroom were: audiotapes, observation checklists, and students' notebooks that included journal questions, group and individual processing forms, and questionnaires. The data were collected during a 9-week quarter; a week-by-week description follows.

Week One

During the first week of the quarter, there were three main components of the study: (a) the students were audiotaped and observed during the first phase of the pilot study, and this continued throughout the study; (b) I kept a notebook for journaling; and (c) the students and their parents completed the pertinent forms.

Audiotaping was the major source of data. The cooperative learning groups were audiotaped on a daily basis as soon as the physical aspects of the recorders, extension cords, and placement of groups were settled. The groups were observed often and for various lengths of time. I asked observers to stop in for a short period of time or stay for the majority of the class period. The observers eventually completed observation checklists that served as one source of data.

Merriam (1998) suggested the use of an audit trail where the researcher described in detail how the data were collected, how the categories were derived, and how decisions were made throughout the study. I kept a journal that served as a day-to-day summary of what was planned, what actually took place in the classroom, comments about the events of the day, and comments about how the cooperative learning was progressing. It also included a daily running commentary on the data collection aspect of the study. The comparison between my journal and students' journals aided in presenting a multi-dimensional insight into the proceedings. My journal focused on what would happen during each class period and any adjustments that were made. That list included items like: fill in communication T-chart, assign topic for journal entry, or was even as brief as stating, "Day went well." This translated to mean that nothing needed to be adjusted to the original lesson plan. As at the beginning of any new process, it was hard to judge the length of time that an activity would take, so to complete everything as intended was a welcomed rare event. My journal began simply as a list of items that needed to be completed. Items on the list included: get observers lined up, get parents' and students' signatures, pass out folders, copy questionnaires, and compile demographics of the classes. As the preliminary components of the process

were completed, other elements replaced them. The elements included (a) put group numbers and students' initials on tapes; (b) check tape recorders; and (c) tape down extension cords. The ideas for changing the observation checklists were noted in this journal and revisited as refinement of the instrument took place.

Week Two

There were three main ideas covered during the second week of the quarter: (a) the students' notebooks were distributed, (b) the general concepts of cooperative learning were presented to the students, and (c) the cooperative learning activities began. The participants in the geometry classes continued experiencing the typical data collection, which consisted of being audiotaped and observed.

The students worked in cooperative learning groups two or three times per week. In each of these cooperative learning sessions, the groups were audiotaped. The presence of a tape recorder could have affected the behavior of the recorded individuals such that it became atypical. In an attempt to make the presence of the tape recorders as unobtrusive as possible, they were used for several weeks prior to the actual collection of data. The students were audiotaped on a regular basis and did not know what data would then be analyzed. Eventually, the students seemed to ignore the audiotapes, as evidenced by the carefree discussions that took place. They would occasionally remind each other that the tape recorders were recording.

Distribution of Student Notebooks. At the beginning of the cooperative learning process, the students received notebooks that were folders with three center brads. These notebooks contained journal pages, questionnaires, group processing forms, group

work, cooperative learning handouts, and all other work pertinent to the study. The journal pages recorded daily progress, positive and negative comments about both class work and cooperative learning, and feelings before and after the implementation of cooperative learning.

The students' notebooks were carefully handled to respect confidentiality. The students did not use their names in the journals; instead, they used different colored folders with different stickers for identification. This process was intended to allow the students to be honest in responding in their journals.

Questionnaires were included in the students' journals. The questionnaires assessed the students' attitudes and opinions about cooperative learning, their feelings about working independently or in groups, their feelings about helping and being helped, and their feelings toward the class and the school (see Appendix L). The first questionnaire was a teacher-made 15-question Likert Scale attitude survey. Sample questions were: I prefer working independently, I prefer working with someone else, I enjoy helping others, and I will let others help me. The choices were *agree*, *disagree*, or *unsure*. I requested that the students complete this form and also complete several journal entries with reference to it. I wanted the students to see if they felt any differently after working in the cooperative learning groups than they had anticipated at the onset.

Also included in the students' notebooks were individual and group processing forms. The groups completed these forms after each cooperative learning session. The individual form had questions that began with the term "My." The students had to analyze their role (teacher-assigned and self-assigned) within the group (Appendix N).

The group processing forms began with the term "We." The students had to analyze how the group performed as a unit (Appendix P). The groups also related these processing forms to journal questions. After several groups stated the need to be better at quiet voices, a journal entry that asked for suggestions seemed to be appropriate.

Introduction of general concepts of cooperative learning. The groups of students in the two geometry classes in which the data collection took place were introduced to cooperative learning. I explained what previous research I had conducted on cooperative learning and why I thought it would be beneficial to them, both academically and socially. I relayed two key concepts: the best way to learn is to teach and we remember more when we are an active participant rather than a passive observer (Appendix S). I explained the major components of cooperative learning: positive interdependence, individual accountability, group processing, collaborative skills, and face-to-face interaction (Appendix T) and what it meant to be a group (Appendix U). I also explained to the students several different types of cooperative learning activities in which the class would be involved. Only some of these activities would render data to be used in the study.

Implementation of cooperative learning activity. The first activity was chosen to demonstrate to the students that cooperative learning should be a positive experience. One non-academic activity that the students participated in was a handout on counting right triangles (Appendix V). The students were individually given a diagram and were asked to count the number of right triangles. The handout contained a basic diagram and allowed for the discussion of how different students arrived at their answers. Each student was then given a more complicated version of the right triangle question. The

diagram was significantly more confusing. For homework, the students had to do what they could alone. The next day each was grouped with students who had different solutions. Each student had to explain the theory behind his or her answer. Each group had to arrive at a pattern that led to an agreed-upon solution.

Students made nametags that were displayed on their desks. The nametags contained their initials, a group number (1-7), a member number (1-4), a member letter (T-E-A-M), a group color (yellow, brown, etc.), and the letter of the group's audiotape. The cards were very helpful to the observers in monitoring student roles and identifying selected students in the Numbered Heads cooperative learning activity.

Week Three

The students remained working in their cooperative learning groups two to three times per week. The standard data collection of audiotaping, observing, and adding to their notebooks continued. Homework was being done in small groups. The goal of this week was to give the participants more time to get acquainted with the process of data collection and become desensitized to the recorders and observers.

Week Four

During Week 4, there were three main objectives: (a) introduction of the Placemat activity; (b) implementation of aspects of cooperative learning; and (c) collection of data from this activity for the purpose of the study. The standard data collection of requiring student notebooks, including processing forms and journal entries, observing, and audiotaping remained consistent.

Introduce the Placemat activity. Placemat, also known as Uncommon Commonalities or Windows, was a team-building activity introduced by Kagan (1994). This activity allowed group members to become familiar with each other. The students tried to find commonalities among group members that separated their group from other groups. Suggested items included: favorites (food, school subjects, sports, hobbies), places they have or have not visited, family (number of family members, type of family, kind of house), cars, music and pets. The verbatim directions given in Chapter IV could be summarized as: (a) one student draws a rectangle; (b) next student connects corners of the rectangle to corners of the paper; (c) next student numbers all sections; and (d) the students begin recording commonalities. The teams rotated the paper to record commonalities and this continued for a designated amount of time. At the conclusion of this part of the activity, each team studied section four, which represented their uncommon commonalities, attributes that were common within a group, but not within other groups in the classroom. In addition to the uncommon commonalities, the group members listed ten positive adjectives on the back of the sheet. Each group made up a name that consisted of one of the positive adjectives and one uncommon commonality. They arrived at a catchy name and recorded it in the middle of the placemat. Each group member initialed it to demonstrate agreement. Placemat was used to help students get acquainted and build team identity. Group members were able to become familiar with each other in a non-threatening way. It enabled the group members to see the similarities within their group, not the differences.

The Placemat exercise, including directions, took approximately 40 minutes. After each group had a name, the shortest person of each group presented the name and

the reasoning behind it to the class. The placemats were then hung up near the group members' seats.

Implement aspects of cooperative learning. The Placemat activity was chosen to address the students' social skills. The specific social skills the students worked on were taking turns, keeping on task, using quiet voices, role-playing, and listening. To address taking turns, the students rotated the paper and the supplies after each comment. Only the student with the paper was permitted to record a common group trait. The taskmaster was assigned to keep the group on track to finish the assignment. Teacher-assigned cooperative learning roles were the runner, the question asker, the taskmaster, and the quiet keeper. In addition to the nature of the activity, to further ensure positive interdependence, I used cooperative learning roles, a final group name, the sharing of materials, and rotating the paper. To ensure individual accountability, the students took turns arriving at an uncommon commonality and signed the final group name to show agreement. A cooperative learning lesson plan worksheet was completed for each of the three activities (Appendix Q). This worksheet was my verification for which cooperative learning elements were going to be covered in the lesson and how the goals were going to be accomplished.

Collect data. The conversations audiotaped during the Placemat activity were saved and later transcribed. The observers completed the observation checklists and students added a journal entry and two processing forms to their notebooks.

The prompt for the journal entry was to name something about each group member that they did not know prior to class that day. The processing forms prompted

students to see what type of learner/worker they were and if cooperative learning could help any shortcomings they possessed.

Week Five

During Week 5, the students continued to keep their journals and continued to be observed and audiotaped without knowing what data would be used. The students worked in their cooperative learning groups, but none of the data from the discussions was saved to be used later. The students completed a questionnaire entitled *Working* (Appendix M). The purpose of *Working* was to assess personal habits, skills, and styles that were associated with a positive work ethic. The population of high school and college students and potential employees fit with this study. The purpose of *Working* in this study was to provide another means of data to show the students how their teamwork position started and ended as the cooperative learning activities continued. The questionnaire, when scored, gave students a teamwork score. For this study, the questionnaire was used merely as a discussion tool.

Working was a self-assessment designed to address nine broad-based competencies associated with high-performance workplaces and based on findings of the Secretary's Commission on Achieving Necessary Skills (SCANS) (The U.S. Department of Labor, 1992). The workplace skills framework proposed by SCANS and others went beyond the basic skills in reading, writing, and mathematics. Thinking skills and competencies in understanding systems, technology, resource allocation, teamwork, and acquisition-analysis of information were viewed as essential for jobs in an increasingly competitive, technologically sophisticated, global economy.

Working was part of a series of products labeled "the mindful workforce portfolio" designed for transitioning from school to entry-level work. *Working's* nine competencies provided a framework of broadly defined, applied learning competencies that were not targeted to specific jobs or groups of occupations. The competencies were not skilled-based in the traditional sense of job analyses and personnel selection, but rather broader, enabling skills and productive work behavior to be assessed. The working in teams competency measured the degree to which one is comfortable working in teams and using skills associated with effective teamwork.

Week Six

During week six, there were three main objectives: (a) introduction of the Numbered Heads activity; (b) implementation of aspects of cooperative learning; and (c) collection of data from this activity for the purpose of the study. The standard data collection of journaling, including processing forms and journal entries, observing, and audiotaping remained consistent.

Introduction of Numbered Heads. Kagan's (1994) Numbered Heads was used to review for a chapter test. The most important component of Numbered Heads was positive interdependence. That was the idea that it was not enough for one student to understand; each student must ensure the understanding of all group members. If a student didn't understand, it was that student's responsibility to ask other group members for help until the concept was understood.

The directions given to the students were as follows: "I will give you a problem. I want your entire group to work it out and then I'm going to call a number and a team at

random. That person goes to the board and if they can show us the work correctly, from their paper only, everyone on the team will get an extra credit point. So you want to make sure you know how to do it and also to make sure other members of your team can do it."

The day before the activity, each group was assigned a section from the chapter; they were to construct review questions. Each group member constructed two questions. The group discussed the questions to check for accuracy and appropriateness and then transferred the questions to index cards. The students wrote the question on the front and the answer, including the work, on the back. The note cards were turned in and used as the question bank for the Numbered Heads activity. Any unused questions were given to the students for further personal review. Each group was assigned a number from one to six and a die was rolled to signify the group that was chosen. Each member of the group was assigned a color and a marker was chosen from the four colored markers to signify the member that was chosen. For example, the teacher may have chosen *four red*. That represented group *four* and student *red*.

If the chosen student was correct and had the appropriate work on his paper, each member of the group was awarded one point. If that student was incorrect, the group that made up the question showed the class how to solve the problem and each member of that team earned one point. The object of the second part of the point system was to maintain a high level of questioning. The activity, including directions, lasted forty minutes.

Implementation of aspects of cooperative learning. Numbered Heads was chosen to address positive interdependence. To ensure positive interdependence, the students

were assigned the roles of the quiet keeper, taskmaster, runner, and question asker; and the team was given extra credit if the chosen student had the correct work and answer. To address individual accountability, the students were expected to submit completed questions and were administered an individual test the following day. The students concentrated on role-playing, peer assisting, encouraging, listening, taking turns, making sure everyone understood, using quiet voices, and developing the "skills to work on" from the last group processing sheet.

Collection of data. The conversations that were audiotaped during the Numbered Heads activity were saved and transcribed to be used in this study. The observation checklists were completed. The students added a journal entry and two processing forms to their notebooks. The students had the last 10 minutes of class to complete the individual and group processing forms and to begin their journal entry which was in response to this prompt: Which question gave you the most trouble? Do you now know how to do it? Give one strategy that helped your group work on your skill from the last processing sheet.

Week Seven

During Week 7, there were three main objectives: (a) introduction of STAD; (b) implementation of aspects of cooperative learning; and (c) collection of data from this activity for the purpose of the study. The standard data collection of journaling, including processing forms and journal entries, observing, and audiotaping remained consistent.

Introduction of STAD. Adjusting Slavin's (1995) STAD, the researcher assigned students to four-member learning teams. The teacher presented a lesson, and then students worked within their teams to make sure all team members mastered the lesson. Then, all students took individual tests on the material; at this time they could not assist one another. Students' test scores were compared to their individual past averages, and points were awarded to each team based on the degree to which students met or exceeded their own earlier performances. These points were then added to form team scores, and teams that met certain criteria earned other rewards.

The main reason for using STAD was to motivate students to encourage and help each other to master skills presented by the teacher. If students wanted their team to earn team rewards, they helped their fellow group members learn the material. They encouraged their fellow group members to do their best and expressed norms that learning was important, valuable, and fun. Students worked together after the teacher's lesson. Students were permitted to work in pairs and compare answers, discuss any discrepancies, and help each other clarify any misunderstandings. They may have discussed approaches to solving problems, or they may have quizzed each other on the

content they were studying. They worked with their fellow group members, assessing each others' strengths and weaknesses to help them succeed on the tests.

Although students studied together, they did not help each other during the test. Every student had to know the material. This individual accountability motivated students to do a good job of explaining to each other; the only way for the team to succeed was for all group members to master the information or skills that were taught. Because team scores were based on students' improvement over their individual past records, all students had the chance to be a team star in a given week, either by scoring well above their past record or by getting a perfect paper, which always produced a maximum score regardless of students' past averages.

While tests were taken individually, bonus points were earned depending upon the improvement scores of group members. This was done to encourage both individual accountability and group responsibility.

The directions and breakdown of STAD were given to the students the day before the activity. The teacher avoided taking any time out of class to review the directions. The activity involved congruent triangle proofs. Many students found this topic difficult. For this activity, the students were given envelopes that contained pieces of proofs. The front of the envelope contained the picture, the given information, and what was to be proved. Each envelope contained pieces of the proof that had been cut apart. The students worked together to try to put the steps in order. Some envelopes contained only the statements, some only the reasons, and some contained both the statements and the reasons. After agreeing on the order of the pieces in the envelope and filling in any missing steps, the group received the teacher's approval and transferred the

correct steps to a worksheet that was later used as a study guide. The students were assigned a worksheet for homework. The worksheet contained all of the proofs that the group did together in class, as well as others that were similar to those completed together.

Implementation of cooperative learning. STAD was chosen for this activity because of the difficult nature of two-column deductive proofs. The teacher believed that incorporating STAD into the lesson would increase the students' incentive to do well, or at least the students would achieve better than they would have otherwise. The assigned roles were taskmaster, encourager, runner, quiet keeper, and all students were to check for "three then me." Kagan (1994) noted that, when first assigned to teams, students raised their hands and expected individual attention. One alternative to this was having a rule: team questions only. If a student has a question, he must first try to get it answered within the team. If no one was able to help, then four hands, rather than one, go up, signaling a need to consult with the teacher. "Three then me" was a phrase used to clarify that a student must ask three members before asking the teacher.

Students focused on listening, role-playing, and taking turns. Role-playing was especially important in this activity because the student who knew how to do the proof had to sit quietly and help the other students develop the skills needed to solve proofs on their own. If the brighter student did the proof for the group, the other students would not be able to earn improvement points that would also help the brighter student. It was very beneficial for every member to contribute to the proofs and begin to acquire the thought process needed to solve proofs.

Collection of data. The conversations audiotaped during the Numbered Heads activity were saved. These conversations were transcribed for use in this study. The observation checklists were kept for future use in this study. To their notebooks, the students added a journal entry and two processing forms. Individual and group processing forms were also completed. In the journal entry, the students had to discuss STAD and what benefits and drawbacks they experienced while preparing for a test using it.

Week Eight

Although the students still worked in cooperative learning groups, they were no longer audiotaped or observed. The students completed another attitude form and the final journal entries while still working in their cooperative learning groups. The attitude form was provided to give students a final look at how their ideas about cooperative learning had changed after implementing it for an entire quarter. One journal entry asked the students to assess the progress made during the quarter. A second, related journal entry asked the students to reflect on their feelings and thoughts about cooperative learning and their involvement in the study. They were expected to list positive and negative points and places for improvement. No verbal responses from this week were used in the data collection. I sent thank-you notes and candy to the observers. Data collection ended because the students were required to prepare for and take their final exams.

Summary

The three data collection methods used in this study included audiotapes, observation checklists, and students' notebooks that were comprised of journal entries, processing forms, and questionnaires.

The students were audiotaped often, but they were unaware which sessions would be used in the study. The three class periods pertinent to this study were saved on audiotape. These audiotapes furnished an objective record of the students' actions, speech, and participation during each cooperative learning activity.

The students were observed during three cooperative learning activities. The observers completed a checklist of behaviors. Observers were often in the classroom before the data collection began. This enabled the observers in the study to feel confident that the students' actions were genuine and minimally affected by them. The observers also commented on the format of the checklist and general feelings about the groups.

The students each kept a personal notebook during the cooperative learning study. The pertinent data in the notebooks included several journal entries that were either related to the geometry lesson or to the cooperative learning investigation. The journals also included individual and group processing forms. The final component of interest in the students' journal was the attitude surveys in which each student ranked, among other things, his or her level of cooperation and desire to work in a group. I, the teacher/researcher, also kept a journal that included a day-by-day lesson plan as well as a recap of each day's events.

This chapter described the design and rationale of qualitative research and case study research. For this study, descriptive case studies were developed from data gathered in observations, audiotapes, and student notebooks. Thick rich description has been achieved through classification of students' communication segments regarding the level of interaction and the level of on-task comments. A multiple-case study was employed to examine the discussions of two groups of students who worked in cooperative learning groups. The final outcomes have provided a resource for math teachers.

CHAPTER IV

CASE STUDY: GREEN

Introduction

This study examined the discussion among students in cooperative learning groups. The communication segments were reported while the students participated in three different activities. This chapter described and analyzed the data collected from the GREEN group in order to gain a better understanding of the interaction in a cooperative learning setting. The chapter was divided into three sections: group profile, introduction of activities, and findings. The group profile described the personalities and showed the traits of each member. Three activities were designed to engage students in cooperative learning. These activities were Placemat, Numbered Heads, and STAD. The introduction of activities described each activity used in the study and explained why it was chosen. The data were compiled after analyzing transcripts of student discussions, observation checklists, and student notebooks that included journal entries, processing forms, and questionnaires. The findings focused on an attitude change toward cooperative learning, trust-building, group regulation, and the facilitation of math learning. The hope was to support the research questions looking at interaction patterns and student learning experiences in cooperative learning groups. The names of the participants have been changed to ensure confidentiality.

GREEN Group Profile

The GREEN group contained three members: Jeff, Mary, and Heather. All three members were freshmen in an accelerated math program, but had little else in common. Mary was outgoing and a fun person to be around. She struggled not only to understand the process, but also to get the correct answer; she never gave up. She was a natural leader and demonstrated her leadership abilities as she tried to keep the group on task and directed toward the goal. She was patient while she worked on group regulation. Heather, who is shy, believed she was strong enough at math to complete the work independently. She would do what was expected, so she worked with the group to reach the desired goal. Although a quiet leader, she also redirected the group as needed to reach each goal.

The dynamics of this group were particularly interesting because of Jeff. Jeff had been identified with special needs and met with an Intervention Specialist one class period during each school day. Although Jeff's academic skills were above average, his social skills and organizational skills were exceptionally low. Jeff had been diagnosed with Asperger's Syndrome, one type of autism. Children with this syndrome have problems with skills in social interactions, particularly with peers. Children with Asperger's Syndrome exhibit clumsy, nerdish social skills and become frustrated by their lack of social success (High functioning, 2005).

Jeff exhibited several characteristics of autistic students. Some of these characteristics were being socially awkward, finding comfort in routine, and having the ability to memorize. Contrary to typical autistic students, Jeff was able to solve problems. While he was able to memorize facts, he was also able to apply those facts to

solve problems. Often in other classes, Jeff took notes and tested on a word processor because his handwriting was almost illegible. He had odd body movements, especially when concentrating on a difficult task such as a test. Jeff was concerned with himself only and saw others, especially his peers, as nuisances. Jeff preferred following a set routine and had trouble starting or maintaining a conversation.

Jeff was not accepted in some classes or groups. Mary had a brother with special needs; that may have played a role in how she treated Jeff; but whatever the reason, she was the most accepting and patient student in the class with him. Mary directed questions to Jeff in order to keep him involved in the group; she showed interest in his answers and reminded him to be an active participant in the group. While the three group members did share similar apprehensions about cooperative learning, they responded differently during the study. Mary was willing to take charge of the group in order to learn the material and reach each group goal. Heather participated as directed, and at the conclusion of the study, admitted she enjoyed working in groups and enjoyed letting others help her. Jeff was at times defiant, but he reluctantly worked toward the group goals. Details about their group interactions are represented in Table 2.

Introduction of Cooperative Learning Class Activities

Three activities were used in this study. Although the activities differed in academic content, the three activities had strong cooperative learning components: positive interdependence, individual accountability, and group processing. In the Placemat activity, students were to work together to find common traits and then incorporate one of these traits into a group name. Students used the Numbered Heads

activity as they completed practice problems. If called upon to explain the correct answer, one member of the group could earn extra credit points for everyone in the group. STAD allowed students to work together on geometric proofs during a test review.

Table 2. Profile of group members

Mary	Mary was apprehensive about cooperative learning from the beginning, but gave it her best. She was well-suited for group leader because she had strong organizational skills, people skills, and a strong foundation in math. Mary was very willing to ask for help when she was entirely lost or even a little confused; she was slow and direct when explaining to someone else. Mary's strength in school was in art, but she still tried her best in math class. Mary was popular, outgoing, and had a positive way about her.
Heather	Heather preferred working independently to group work but, like Mary, kept an open mind during the cooperative learning activities. She was a positive contributing group member, but not a leader. Heather was shy and soft-spoken and would do nothing loud or embarrassing. She was very good at math but enjoyed English class the best.
Jeff	Jeff was sure that nothing good could come from cooperative learning. He did not want to take the time to help others and did not want others helping him in what he considered his best subject. He would not ask for help and when it was offered, he would either argue or ignore and do his own thing. He had a hard time adjusting, but by the end of the quarter, with two very understanding group members, he was able to enjoy the cooperative learning experience. As Jeff noted in his attitude questionnaire at the conclusion of the study, he still would prefer to work alone, but enjoyed the activities.

The mathematics classroom should ensure the acquisition of the math content as well as build social skills in the students. Students developed math knowledge by investigating, discussing, and validating. In order to accomplish this knowledge base, students must communicate. Communication segments were reported while the students participated in three different activities: Placemat, Numbered Heads, and STAD.

Placemat, a nonacademic activity, was used for the group to get acquainted and build a basic level of trust; Numbered Heads was used during completion of a worksheet to reinforce the idea that the group will outperform the individuals; STAD was used as a test review to show the academic benefits that may occur during cooperative learning. While completing the Numbered Heads and STAD activities, students were also able to facilitate their math learning by talking to each other about the reasoning processes.

Placemat

Building team camaraderie was an important aspect of cooperative learning. Placemat helped build a sense of comfort among group members as well as a sense of belonging (Kagan, 1994). In Placemat, the group was trying to find uncommon commonalities, which were traits common within their group, but uncommon to other groups.

In order for the reader to truly understand and be able to follow the activity, the reader should know what was expected of the students during the Placemat activity. The directions, as given by the teacher prior to the activity, are presented below.

> Okay, what you're doing today is called Placemat and it's a cooperative learning activity. The first purpose of it is for team building. Number two is group cohesiveness. Number three is to make you comfortable enough in your group that you're not afraid to give an answer. So that's the point behind it. Maybe you will learn something about someone in your group that you didn't know, that you think is pretty neat. You are trying to find . . . uncommon commonalities, which means this group is trying to find something common to the four of them that is not common to everybody else. So, common to them would not be 'I'm in geometry class first period.' That doesn't count because that's not common to that group versus everybody else. This is what you're going to do. The runners are going to come and take a piece of typing paper, markers, and a ruler. The first thing you're going to do, you're going to list ten positive adjectives on one side. On the other, it's called a Placemat . . . let me show you

> what this will look like. If you have a group of three, you draw a triangle in the center and then you connect each vertex and you number it one, two and three and leave the center blank. Then I say something like 'I was born in Virginia.' If I'm the only person that has that trait, I write that trait here. Rotate the paper. The next person may say I have four dogs, and somebody else in the group also has four dogs, so there are two of us in the group that have four dogs (teacher shows 'has 4 dogs' written in section 2). And somebody else says my favorite ice cream is chocolate and then everybody in the group agrees that our favorite is chocolate (teacher shows 'favorite ice cream is chocolate' written in section 4). And you just keep rotating it. In about ten minutes after we begin, I will stop you and then I will give you the next set of directions, okay? This is blank for now. Now, if you have four people in your group, the only difference is you have a square or a rectangle and you'll have numbers one, two, three and four. So if every person in the group agrees, you write here; if you're the only one, here; if there are two of you, here, etc. Any questions at the beginning? People will be coming in and observing; please ignore them as usual. I need the runners. Make sure the taskmasters are keeping people on task. Make sure the quiet keepers are enforcing 12" voices, and the encouragers . . . you know what to do. Quiet voices, please, which means I shouldn't hear you.

Figure 2 presents the outcome of common traits after completing the Placemat activity.

While rotating a piece of paper and suggesting topics, the students developed the replicated "Placemat." If the topic were related to only one student, it would be recorded in the space numbered 1. If two students shared the topic, it would be recorded in section 2. If all three members shared the topic, it would be recorded in space 3. From among the common traits, those in space 3, the students selected one to use in a group name.

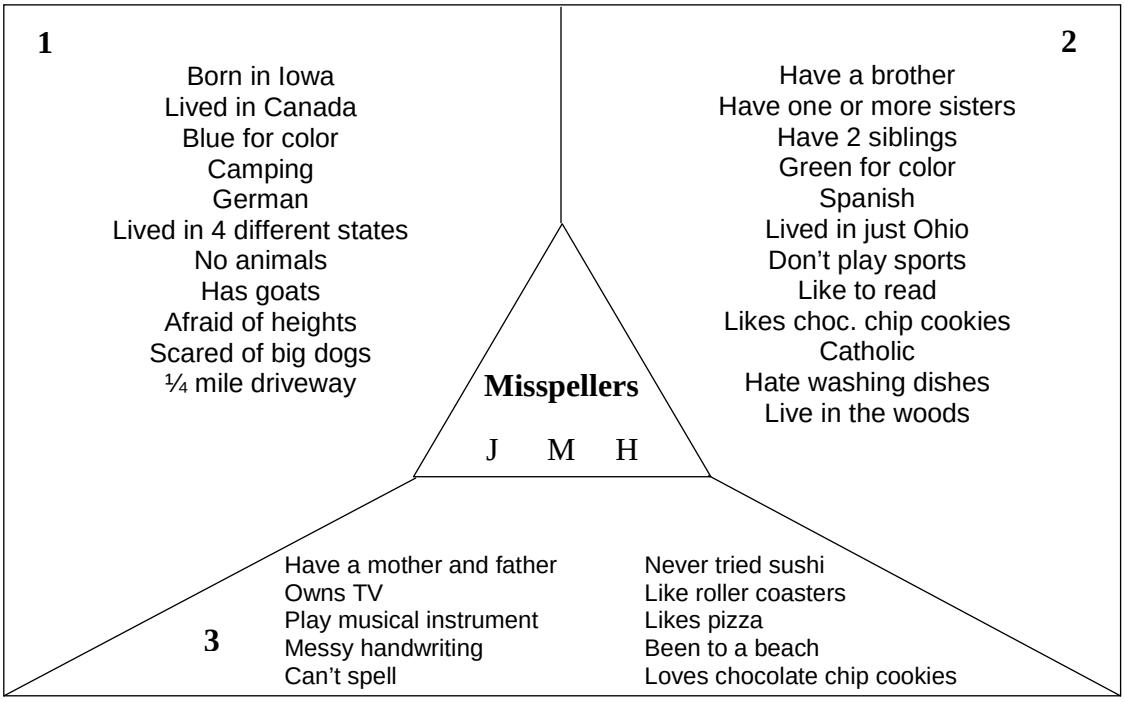


Figure 2. Outcome of common traits from Placemat activity

After finding enough common traits within the group, students were then directed to list ten positive adjectives. One of these positive adjectives would later be incorporated into their group name. Figure 3 presents the outcome when listing ten positive adjectives during the Placemat Activity.

The second set of instructions was given after the groups had enough items listed in the highest uncommon commonality, space 3. The teacher then directed the students to find a group name.

> Okay, I think you guys have a good start. Now you are going to combine one of your positive adjectives with one of your topics in the section marked 3 to come up with a name and put it in here in color with your initials. For example, 'the happy cat owners.'

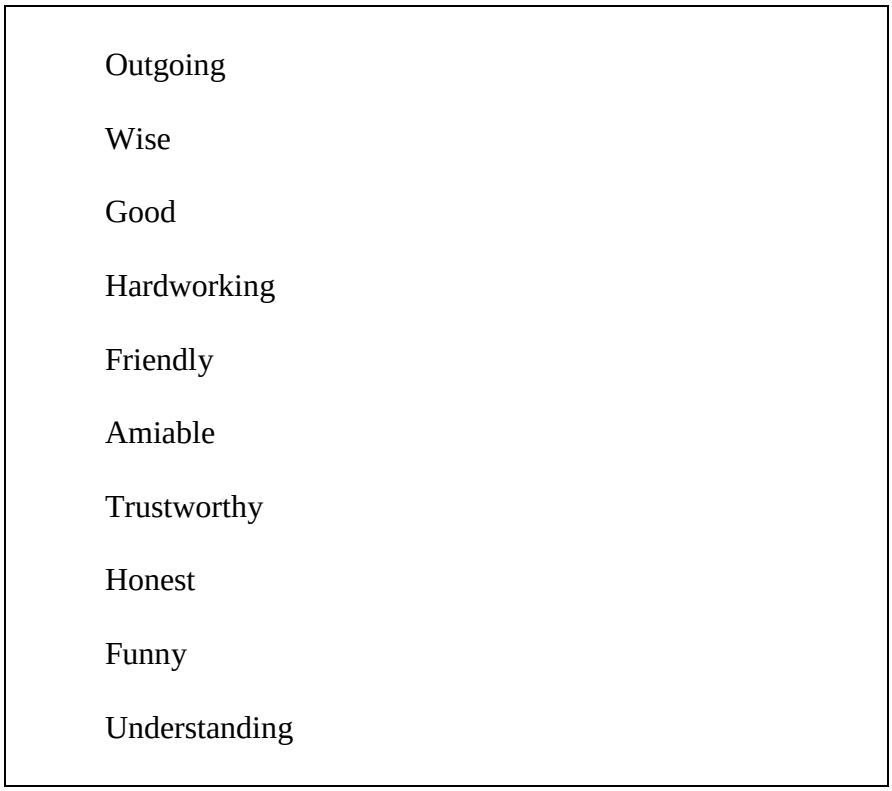


Figure 3. Group outcome of positive adjectives for Placemat activity (back)

Placemat was chosen as an activity for data collection because the search for uncommon commonalities served not only to help students get acquainted, but also served to build a team identity when the team used one of the uncommon commonalities to design a team name. Each student within the group had an equal opportunity to share. At any one moment, all of the students were actively engaged in purposeful speaking and listening. Another of Kagan's strategies that was employed during this activity was roundtable. In roundtable, students took turns contributing to the group, in an oral or written form. There was usually one piece of paper and one pen for the team. One student made a contribution and then passed the paper and pen to the student on his or her left. The paper literally went around the table, thus the name roundtable (Kagan,

1994). For this activity, however, each member of the group had a different colored marker. The idea was to get everyone's ideas; the markers and rotation of paper should have contributed to this.

The activity was chosen so the group members would become comfortable with each other. The idea was that if a certain comfort zone were established, the group members would be more likely to ask a question of another group member. This activity also allowed all group members to have an equal contribution because it was not based on academic expectations. Every member had a different colored marker and circulated the paper; therefore, it was easy to see the amount of writing which was tied to individual contributions.

Numbered Heads

Positive interdependence was an important aspect of cooperative learning. Kagan's Numbered Heads addressed this need for the group to feel that the group could perform better when working together than as three or four individuals (1994). Each student within the group had an equal opportunity to share. And at any one moment, all of the students could be actively engaged in purposeful speaking and listening.

Numbered Heads could be used to strengthen the processing of information by students, the communication within groups, the development of critical thinking skills, and the process of reviewing material. Several cooperative learning skills were addressed by Numbered Heads. These skills included: sharing information, listening, asking questions, summarizing, and talking quietly.

The following five steps encompassed this activity:

1. Each student in a group was assigned a number 1-4. The teacher could assign numbers or students could do so themselves.

2. The teacher asked the students to solve a math problem. It must be stressed that everyone in the group must be able to participate and answer the question. The expectation was that everyone in the group would be able to answer the question following the discussion. The teacher ensured that enough 'wait time' was given for the group to complete the task.

3. The students worked together. They literally "put their heads together" in order to solve the problem and also to ensure that everyone in the group could answer the question.

4. The teacher then asked for an answer by calling a group and a number at random. The student identified by that group and number then answered the question.

5. The correct answer earned the reward of an extra-credit point for each member of the group.

Since each member of the group would earn an extra-credit point if the chosen student had accurate work and could explain the process used to arrive at the correct answer, this activity was designed to enhance positive interdependence. It was most beneficial to the group if each member – not just the" bright student" -- was able to earn the points.

The full explanation of Numbered Heads was given the day prior to the actual activity because many students were confused by the wording of the directions. The directions that were given to the students on the day of the activity follow:

> I am going to give you a problem. I want your entire group to work it out. Then I am going to call a number and a team at random. That person goes to the board and if he or she can show us the work correctly from only his or her paper, everyone on the team will get an extra-credit point. So you want to make sure you can do it, and you want to make sure your fellow group members can do it also.

Numbered Heads was chosen for the strong positive interdependence that it ensured within the group. The idea that a student could earn extra credit not only if he knew the correct answer, but also if one of the group members had and could explain the correct answer, should have helped the students recognize the need to understand the concepts themselves and to be sure their fellow group members did also. Numbered Heads also helped keep students on task because the group members were interested in what each other was doing—correctly or incorrectly.

Since the components of Numbered Heads were designed to make students work together, the researcher expected to see a desire not only to get the correct answers but also for the students to help their fellow group members get the correct answer and understand the process used to get that answer.

The Numbered Heads activity was used to help the students review for a test. A worksheet containing eight questions was designed to prepare the students for the test. The students did not receive the worksheet at the beginning of the class period. Instead, the teacher presented the entire class with one question, chosen from a list of objectives to be covered on the test. Each student was assigned a group color and number (GREEN and ONE in this case) and individual numbers (Jeff 1, Heather 2, Mary 3). After the groups had enough time to come to agreement on the process and correct answer and have it documented on each member's paper, the teacher randomly chose a student by a

group number and student number. For example, Jeff was group 1, student 1. There were only four groups in this class and a maximum of four students per group, so a four-sided die was used for random drawing. If the chosen student had the work on his paper, correctly explained the problem to the class, and answered any questions (to show mastery), each group member was awarded an extra-credit point. If this student were unable to complete any of the above items, a new student would be called using the same random method of rolling the die twice, once to designate the group and once to designate the individual. The same group would not be given a second chance on that question. The group was expected to comprehend the value in understanding the material, helping others in the group, and group consensus.

This pattern continued until the end of class. Since all eight questions were not completed, the worksheets, along with the correct answers, were passed out at the end of the period for the students to complete for homework. The students enjoyed the Numbered Heads activity as a method of reviewing for the test. They also enjoyed the extra-credit points they could earn as a group. Evidence of this was given in a later discussion about extra-credit points.

STAD (Student Teams Achievement Division)

Several experts in cooperative learning believed that a reward system based on individual achievement was needed to demonstrate the benefits of cooperative learning. During STAD, students completed tests individually, but they were responsible to ensure that other group members mastered the material also. Extra-credit points were awarded to the group based on the improvement points of each group member. STAD used the

reward system to solidify the idea of individual accountability; not only must each team member know the material, but each must also help the other team members so that all knew the material.

STAD was chosen as one of the cooperative learning activities in this study because of the difficulty of the material for geometric proofs. Since it was an academically challenging topic, the researcher thought the use of STAD would help the students learn the material better and therefore perform better on the test. STAD provided a cooperative learning environment where students should help each other and, in return, understand the concepts better. Students were able to help each other learn better by talking through the steps of the proof until the group was able to complete the entire process.

Each group received only one proof at a time. The steps of the proof were given to the group in an envelope containing the statements, the reasons, or both. Each element was printed on a separate strip. The group members were to work together to organize the information and to fill in any missing steps. When consensus was reached, the teacher checked for accuracy and discussed problems. When everything was correct, the group transferred the information to a review sheet to be used as a study guide for the next day's test. The exact teacher instructions follow. "Get your notes out from yesterday. It will be very, very helpful. Every group should have a proof in an envelope. You will dump out the pieces. Please don't lose them. Work together. Try to get the proofs worked out. The given is not in the envelope; it's on the front of the envelope." These requirements helped the students work in a cooperative learning setting by sharing the tools, reminding each other of past theorems, and completion of

the assignment after all members have brainstormed and reached consensus. The students were expected to demonstrate application of this knowledge of proofs on the next test. These steps facilitated cooperative learning by strengthening the ideas of positive interdependence, individual accountability, and group processing.

Findings

Four themes evolved during the examination of the data after reading and categorizing different data sources. The themes are positive attitude toward cooperative learning, trust-building within the group, group regulation, and facilitation of learning math. There seemed to be a positive attitude toward cooperative learning while the students worked in the group; this change in attitude came after anticipated resentment toward the idea of cooperative learning. The groups developed a level of trust that enabled them to be able to express views and answers without fear of abandonment by their fellow group members. Group regulation was noted when the members helped each other, kept each other on task, and encouraged each other. Finally, there was evidence to support the facilitation of math learning. The researcher focused on analyzing student interaction during the work in the three cooperative learning activities with the two-fold hope of identifying the process and characteristics of the interactions and learning about student experiences. The study lasted nine weeks. In order for the students to become accustomed to the visitation of observers and the placement of the tape recorders, data was not collected for three weeks. The researcher did not expect either the observers or the tape recorders to affect the interaction of the students. Placemat was used during week four, Numbered Heads during week six, and STAD

during week seven. After quite a bit of anticipation to use cooperative learning, the group members, who originally had little in common, were able to establish a strong sense of comradeship and trust.

Before participating in the three activities, a self-report Math Attitude Questionnaire revealed that Heather did not like working in groups and Jeff was unsure about working in groups. Mary, on the other hand, preferred to work in pairs rather than a group, but was willing to give cooperative learning (in groups) a try. The members of this group helped each other because they wanted to complete each assignment. The level of help, however, was quite different. Heather was a good group member because she included herself in most conversations, either by starting a question or answering someone else's. Mary wanted everyone to participate and politely reminded Jeff that the group needed to stay together in order to complete the assignment. Jeff was often distracted, but still wanted the good grade that would be earned upon completion of each activity. The results that the GREEN group showed were evidence that, despite some of the members' apprehension, each enjoyed the cooperative learning experience. At the beginning, two students were not convinced that cooperative learning was a positive thing; however, both responded that they liked working in groups when they completed the Math Attitude Questionnaire that was administered at the completion of the study.

Attitude Change Toward Cooperative Learning

From the observations, student journals and questionnaires, and transcripts of student communications during each activity, it is noticeable that there was a change in attitude toward cooperative learning. At the beginning of the activities, all three students

were apprehensive about working in teams and saw little benefit to cooperative learning. While working on the activities, the members began to appreciate the availability of other viewpoints and support. Upon the conclusion of the study, the students changed their attitudes toward cooperative learning. All three students stated that they would like to do more cooperative learning activities and also that they had found some benefits in working in a group. In order for cooperative learning to have been a success, students had to believe in the idea of the group. This idea that the group could be more successful than three individuals was demonstrated by the members' changes in attitude and their comments in both their self-report questionnaires and journal entries. Students' positive attitudes toward learning math were reflected in the transcripts, observation checklists, and students' notebooks that included journal questions, group processing forms, and questionnaires. Students not only showed a positive attitude toward math, but in some instances showed a positive change in their overall attitudes. Although some students were apprehensive and unsure about the personal benefits of cooperative learning, they expressed enjoyment and enthusiasm toward cooperative learning and mathematics.

During Numbered Heads, students worked together to come to a consensus about the correct answer to a problem. If a randomly chosen student was able to describe the process and had the correct answer, each team member was awarded an extra-credit point. The following communication segment showed the students discussing extra-credit points (PODs). Jeff was discussing his extra-credit points while the girls expressed their enjoyment with the game.

J: Now we get another one? I've got so many PODs this quarter. Let's see, I've got like, one, two, and then I got two for these problems today and another one from our homework from last week.

H: Oh yeah, that's right.

M: I like this game.

H: This is a fun game.

A positive change in attitude was noted on the Math Attitude Questionnaire when Heather and Mary had a change of opinion on the topic of "will enjoy cooperative learning." Both girls were unsure about the statement before beginning the study, yet both girls agreed with the statement (enjoyed cooperative learning) at the conclusion of the study.

Heather demonstrated a shift in attitude toward cooperative learning when she responded to the WORKING questionnaire (administered before the study), indicating that she only occasionally liked working in teams. At the conclusion of the study on a Math Attitude Questionnaire, however, she responded in agreement with the statement "like working in groups." This is mirrored in Heather's Individual Processing Form where she listed the behavior that she felt particularly good about as contributing equally to the group's goal. In Heather's first journal entry, she showed her apprehension toward cooperative learning when she warned against wanting to work with people who might be rude, obnoxious, or disgusting. In her final journal entry, she showed a level of satisfaction about cooperative learning when she stated that she wouldn't mind doing it again. Table 3 documents the attitude changes after their participation when the students responded to the Math Attitude Questionnaires.

Table 3. Attitude changes according to pre- and post-Math Attitude Questionnaires

		Agree	Unsure	Disagree
Prefer working independently	Pre-	H	M, J	
	Post-	H	J	M
Like working in groups	Pre-	M	J	H
	Post-	J, H, M		
Will enjoy cooperative learning	Pre-		M, H, J	
(Enjoyed cooperative learning)	Post-	M, H, J		
Enjoy helping others	Pre-	M	J, H	
	Post-	J, M	H	
Will let others help me	Pre-	M	H	J
	Post-	H, M	J	
Am a cooperative person	Pre-	M	H	J
	Post-	H, M	J	

There were six areas about working in groups where the researcher noted a change in attitude. In the first statement, *prefer working independently,* in the pre-, Mary said *not sure*, but toward the end, she responded *disagree*. Heather stated that she agreed to the statement during both the pre- and post- questionnaires. Jeff responded *unsure* on both questionnaires. In the second statement, *like working in groups*, Mary had *no change* in attitude. Heather's response changed from *disagree* to *agree* and Jeff's changed from *unsure* to *agree*. In the third statement, *will enjoy (or enjoyed) cooperative learning*, all three members had an attitude change from *unsure*, at the beginning of the study, to *agree* at the conclusion of the study. In the fourth statement, Jeff changed his opinion about how much he enjoyed helping others. At the beginning of the study, he was *unsure* about how much he would enjoy helping others, but at the end of the study, he *agreed* with this statement. Both Mary and Heather remained consistent in their answers. Heather was *unsure* in both questionnaires and Mary *agreed*

with the statement both times. In her journal entries, Mary did not change her mind when responding to the statement *will let others help me*; she *agreed* in both cases. Heather and Jeff both had a change in attitude. Heather went from *unsure* to *agree,* and Jeff from *disagree* to *unsure*. In the final statement, *am a cooperative person*, both Heather and Jeff changed their responses during the course of the study. Heather changed her response from *unsure* to *agree* and Jeff changed his response from *disagree* to *unsure*. Mary reported *agree* on both questionnaires. Jeff stated that he was very intrapersonal in math so he naturally liked working better alone. He concluded that it (cooperative learning) helped him work in teams. Although Jeff was still unsure about many aspects of working in groups, he showed positive changes from originally disagreeing. Heather showed a change in attitude in several of the statements. Table 3 documents only those responses that were different from the pre- to the post- attitude questionnaires.

As a classroom teacher interested in solidifying the math content, the researcher noted several benefits that came from the changes of attitude. Although all three students were very strong math students, each one wanted to work alone in fear of getting slowed down when having to help someone else. After experiencing the benefits gained from participating in the three activities, the students were more willing to work together. They were able to get other students' viewpoints that may have mirrored their own. They also became tolerant of differing viewpoints. This was beneficial when the students needed to ask for help and then became comfortable enough with their fellow group members to do so. Students who were able to teach someone else the material had mastered not only the content, but they also had acquired different ways of relaying this

information. Students had minimal cooperative learning experience and that experience they did have was not successful. The students saw previous cooperative learning experiences as unequal participation when the better students lead the group and other students relied on that person to do the work and earn the team credit. They did not realize that working in cooperative learning groups, when set up correctly, would enable them to actually learn better. With the changes in attitude, the students were willing to do other cooperative learning activities that were more academic-based.

Development of Trust

Cooperative learning has inherent components that enable members of each group to build a greater level of trust than when not working in a cooperative learning group. Trust-building includes encouragement, group consensus, and mutual support. This act of trust-building shows the members that the group is a safe environment for sharing ideas, experimenting with different tasks, and making mistakes; thus the groups grow as a collective body. The process of trust-building is developed through working in a cooperative learning group. Trust-building is a process that a group must experience before reaching the desired goal. The process begins when group members have a positive demeanor and are willing to share their thoughts and ideas with their fellow group members. Group members feel safe making mistakes and exchanging ideas that may not be correct. This feeling is encouragement of self-exploration, inquiry, and logical reasoning. The group members begin to see consensus in their ideas, processes, and answers; this leads to interest in others' responses. These are all key elements to foster in mathematics learning.

Placemat is designed to show group commonalities so, this is the first place students from different backgrounds can learn that they have something in common. The members of the group show encouragement and support for each other; they even begin to complete others' sentences when completing the three activities. One student begins a thought, and while hesitating to finish, another student (or students) finishes the communication segment. The students are not being rude and interrupting; rather, they are showing their level of comfort in the group. Trust-building is supported when each student feels that his or her ideas are valuable and valued within the group. This trust-building process ultimately leads to comfort within the group which can only lead to positive outcomes, such as extra-credit points, completion of assignments, and enjoyment of class.

Mary demonstrated her positive demeanor when congratulating her group for a good answer. When doing the Placemat activity, the group circulated a piece of paper and each student recorded a general positive adjective until the group recorded ten. Mary liked the adjective 'amiable' that Heather contributed.

J: Good.

H: Hard working.

M: Friendly.

J: Okay.

H: Amiable.

M: Ooh. Big words, good job.

She also responded in a pleasant way when she said, "Yeah, I like that one."

Mary was constantly showing encouragement to her fellow group members so they would not hesitate to share an idea. This extension of her personality allowed the group to have a pleasant experience while working in a cooperative learning setting.

If a student feels secure, he/she will be more willing to generate ideas or share feelings about their own weaknesses. Jeff talked about his poor handwriting, a characteristic that was also often exhibited in children with Asperger's Syndrome. Within his group, he felt comfortable enough with Mary and Heather that they would not make fun of him. Instead, they shared his characteristic of messy handwriting. While the group was trying to come up with common themes in order to complete the Placemat activity, Jeff stumbled upon a trait that all three members shared. This would not be used in the group name, but it was a trait that the group members were able to share.

J: . . . my handwriting, sometimes it's good, sometimes I can't read it.

M: Oh, same here. Hey, there we go.

H: I have messy handwriting.

J: It changes in subjects.

J: Well, it's not that bad in math class, but it's always bad in language arts.

Although Jeff's handwriting is poor in language arts, this does not carry over to math class. Jeff was very sequential and spread out his steps, a helpful technique that he developed earlier in his schooling. Since his steps were spread out and organized, the teacher could easily follow his reasoning and find his answers. The group also found consensus when discussing spelling. This common theme would later be used to form a group name. While looking at the transcript of the GREEN group's Placemat activity, it was noted that they named themselves "The Wise Misspellers" because they were all

good math students who all had trouble spelling. This was a strong group bonding exercise within a group that seemed to have little or nothing in common. Sharing ideas to find common ground was one way for a group to begin to trust each other, and this type of sharing and bonding was obvious in the following conversation among the three.

H: Which ones do you guys want? How about can't spell? The funny miss spellers and spell it wrong.

J: I like the wise misspellers.

H: That would be funny, because a wise person would know how to spell.

M: Ok, write that down. That's an oxymoron.

H: How do you spell that?

M: M-I-S-S-P-E-L-L-E-R-S. I'm going to put that down on my oxymoron sheet.

After coding the GREEN group's Placemat activity, the researcher recorded 51 communication segments, with only one in which the students were not discussing the activity at hand. That may be a little misleading because the purpose of Placemat was to get acquainted, so what would normally be considered off-task discussion was perfectly acceptable in this activity.

The following discussion about a broken dishwasher would usually be considered off-task in math class, but in the Placemat activity it becomes part of the goal of the task: for the group members to get to know each other, and subsequently gain a higher level of trust. In order to support this trust, the members showed their consensus while discussing chores.

H: What about, what is your least favorite chore to do?

M: That's a tough one. Washing dishes.

H: Me too! Oh I hate washing dishes! That's like my least. Gross.

M: Yeah, like when there's food in the water too, oohh.

J: I just throw them in the dishwasher.

M: See we don't have our dishwasher. It's broken.

Jeff was totally involved in the conversation. This showed the trust he had with his fellow group members. According to his journal, he resisted the idea of wanting to work alone, but once he was involved with his fellow group members, his level of anxiety dropped and he felt comfortable enough to share in the group goal.

According to the observation checklist, the members of the GREEN group were actively engaged. The observer, a high school English teacher, noted that the members were taking turns and most times different people were talking rather than one person dominating the conversation. The observer did not notice any controlling or disengaged member. She noticed that the group members were looking at the speaker and leaning in to show that they were listening and involved with the activity. The observer also noticed there were occasions that more than one person was talking. In a typical classroom setting, this might be a negative quality, but for this activity, it occurred quite frequently in a way that kept the conversation flowing, demonstrating high engagement in the communication and interaction.

The researcher found it interesting to see how this group finished each others' thoughts as they worked together as a team and began to trust each other.

M: Now we need (pauses) . . .

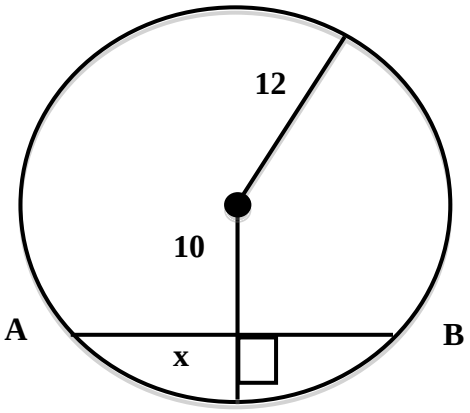
J: Now we need to do the (pauses) . . .

H: triangle thing.

Prior to this class, this group of students had never been in a class together and did not share the same friends, so they would have had little, if any, outside-of-class involvement with each other.

Numbered Heads was used when students were completing problems in order to prepare for a test. One problem was given to the class. Collaborative time was given with the goal that the students would work together to get through the problem. The group was to reach consensus after questioning and convincing other group members. If their group was chosen, one student, chosen randomly, would be responsible for sharing the process and correct answer. Extra-credit points for each student were earned if the chosen student could respond accurately. This process should enhance positive interdependence when each student's extra credit would be earned based on the performance of the group. The group was to solve for the unknown side of a triangle. For a successful session, each member of the group needed to be able to complete and explain the problem. In the Numbered Heads activity, the three individual students were beginning to think as one math student. This was demonstrated when the students were working on a problem and one student suggested a method to use. The other students responded by taking a turn finishing the process that was started by another member. In this example, the students completed questions from a worksheet that they then used as review for a test. The problem dealt with finding a triangle's unknown side length after using several geometry concepts, including the Pythagorean Theorem. The level of comfort within the group was demonstrated when the group was able to have a coherent conversation with many incomplete sentences. Often another group member would finish the thought of the person who began the conversation. It was obvious that the

entire group concentrated on the same topic at exactly the same time. Figure 4 presents a diagram the students used during the Numbered Heads activity.



$$144 = 100 + x^2$$
$$44 = x^2$$
$$\sqrt{44} = 2\sqrt{11} = x$$
$$AB = 2(2\sqrt{11}) = 4\sqrt{11}$$

Figure 4. Diagram used during Numbered Heads.

In doing this problem, Jeff began the process by noticing the right triangle that would be formed when moving the chord with length around until it connects to point A or B. When Jeff got 44 in the process, Heather jumped right in by taking the square root and simplifying that answer to $2\sqrt{11}$. Jeff then took over the teaching role and explained to both girls that the simplified answer was correct.

J: 144 minus 100, that's 44 = B squared.

M: Yep. So . . .

J: So 44 . . .

M: Equals B.

J: I have 44.

H: 2 radical 11. Oops, that's wrong.

J: Yeah 44, no that's not a multiple.

H: 2 radical . . .

M: It doesn't work? It breaks down into um . . .

H: Radical . . .

J: 11. See that's, 2 radical 11.

M: Yeah.

H: 2 radical 11.

M: Yeah.

J: Yeah.

M: Okay. No. It's radical 2, radical 11. No wait, yeah. That's right. Sorry.

J: 2 radical 11.

M: Sorry and then 2 radical 11 plus 2 radical 11 equals . . .

J: 4 radical 11.

M: 4 radical 11.

M: And that's AB.

Immediately the researcher noticed that the group became more relaxed within the group setting because they commonly finished each other's ideas. A free exchange of information, where everyone had something to contribute, seemed to evolve. Although this communication segment seemed "choppy" and hard to read to an outsider, the teacher noted that the students were communicating effectively with each other. The students acted not as three separate members, but as one strong group. This feeling of the strength of the group could not have been obtained without the group gaining the trust that they did in each other. The communication segment showed this continuation of thought by the other group members. If the names were taken out, this passage could almost be spoken by one person. This segment contained peer coaching although Mary

was helping herself also when she talked through her mistakes. In this session, step-by-step coaching was not necessary. The students were talking about math and using math terms; that is always a goal of math teachers. Each student was engaged in the activity and in the process of obtaining the unknown length.

Trust-building was noted in the group when they showed a level of comfort to share ideas and answers. The group members encouraged each other and enjoyed the consensus that they were able to achieve. The group members became so comfortable with each other that they were finishing each others' thoughts.

Group Regulation

Group regulation contained several elements that were examples of effective group work. Some components of group regulation were peer coaching, questioning, monitoring the progress of the group to keep the group together and on task, and completing the assignment. Group regulation was vital in cooperative learning. Each member was responsible not only for his own work, but also for the outcome of the group. Group members must understand what each did well and how this could help the group. Each member also needed to be aware of areas of weakness and work on correcting these in order for the group to function well. A strong component of successful cooperative learning was group processing. In all of the activities, group processing was addressed using individual and group processing forms as well as analyzing the transcripts. After each activity, each member filled out an individual processing form about their own role in the group. The students recorded and discussed what they did well in addition to what they needed to work on. Together the group also

filled out a group processing form that addressed similar questions. Group regulation is exhibited when one or more members tried to keep the group members working together or tried to re-involve an uninterested member. Placemat contained forced group work when each member was responsible for rotating the paper, sharing, and writing down ideas. Since each group member had a different color and recorded his/her own information, it was easy to see the individual involvement. The students were motivated to help each other stick to the task because the group had to come to common points that could not be obtained without involvement from all students. While using Numbered Heads, the students were given a designated time in which to complete each question. This helped the students have the desire to stay on task and complete the assignment (each separate problem). The students used STAD to review for a test on the difficult topic of geometric proofs. The group could not get a new proof until all members had completed the current proof correctly. Since it was review for a test, the more proofs the students practiced, the more prepared they would be.

In group regulation, there needed to be a leader, or several leaders. Mary automatically filled that role. This self-assigned leader position may have been the result of working with her special needs brother or may simply have been part of her personality. Heather was naturally shy and Jeff struggled to act appropriately in group settings. Mary politely showed that she was concerned with the group staying together and finishing the task. She demonstrated her patience and directness to get Jeff involved and keep the group directed toward the task. She also showed genuine interest in her group members' backgrounds, an extension of helping Jeff feel secure in the group.

During the Placemat activity, the group was trying to find common traits that separated their group from the other groups.

H: I was born in Iowa.

J: Anybody else born in Iowa?

H: I don't think so.

M: No.

M: That's pretty cool.

H: It's in the middle of nowhere though.

J: Is it like one of those where you drive for miles and there's nothing on both sides?

M: All right. So you want to go, Jeff? See if you can find one.

J: Okay. I lived in Canada for two years.

M: Did you really?

M (to Jeff): Got any ideas?

Mary was able to show interest in the way she worded her comments and questions. With the level of interest that she showed to Jeff, she was able to keep him working on the task and have him completely involved in the group. She prompted Jeff without telling him to take his turn.

Heather reminded the team that the directions needed to be followed when the group listed positive adjectives and that she was not the only one responsible for writing. Heather demonstrated group regulation and became the leader, although she was naturally shy.

H: Cheerful.

J: Wise.

M: Friendly. Outgoing, outgoing.

H: Actually, you're supposed to be writing them, too.

M: Okay, I passed it.

She again tried to get the task completed when the group seemed to need direction.

H: All right. What else? What else do we have in common?

This direction that Heather was giving the group mirrored her individual processing forms when she rated her contribution as excellent. She also believed her fellow group members would agree that her contribution was excellent. She noted that she needed to work on encouraging her team members.

When analyzing the discussions, the researcher noticed several of them showed Mary watching over Jeff. Mary wouldn't give up if she thought Jeff still needed help and tried to sympathize with his tearing of his paper.

J: 24.

H: Do you need help?

J: No, I'm okay.

H: Okay.

M: Are you sure?

J: It's just that erasing my writing and finding what the numbers were isn't easy.

M: Oh yeah, I hate when my paper does that.

It was interesting to note that although Mary seemed to be so compassionate and encouraging, she did not believe she contributed equally to the group task. She reported in her individual processing form that her cooperation was excellent, but she would work harder at equal contribution. She also wrote that she needed to work on quiet voices within the group.

Overall, the observer noticed many positive group scenarios. She listed the most frequently witnessed positive attributes of the group to be when the students: (a) looked at the example/calculator; (b) leaned in; (c) demonstrated group involvement; (d) showed work to others; and (e) looked at others' work. This was interesting in comparison to students' responses in the pre-study questionnaires; no member of the group was convinced that group decisions were better than individual ones. Each member, contrary to their original apprehensions, was willing to work together for the good of the group. This was a strong statement and indicated that cooperative learning was most successful when three components were present: positive interdependence, individual accountability, and group processing.

In several instances, Mary reminded Jeff to be a part of the group. In this first example, Jeff was preoccupied with finding his name tag to put on his desk and hoarding the paper so the other students could not see it. The teacher saw this not as Jeff's being selfish, but his wanting to do the work on his own.

M: Okay, Jeff, scoot in the triangle with us. Maybe we can all see the thing.

J: I have to find my name tag. No, that's not it. Okay, this time we get the reasons.

M: Here Jeff, just put it down on the desk so we can see.

Mary is still trying to get Jeff to join the group. Each group was given only one set of materials to ensure that the sharing would take place. Mary was asking for Jeff's cooperation.

When analyzing the group processing form for the STAD activity, the group rated themselves as "usually" functioning well together to accomplish the goal instead of "always" functioning well together to accomplish the goal, as they had previously stated for both the Placemat and Numbered Heads activities. The behavior that the GREEN group identifies as "needing to work on" is *participation*, not the quiet voices as previously listed. This showed that they noticed that their cooperation and teamwork needed to be addressed. Items that the group members identified as weaknesses were individual levels of cooperation, what the other members would perceive as their level of participation, level of cooperation, and contributing equally to the group's goal. Jeff noted these as individual weaknesses, or items to work on. Both girls noted that while they believed the group needed to work on cooperation and participation, they both believed their personal levels of effort were good.

Facilitation of Mathematics Learning

The facilitation of the learning of mathematics occurs when students communicate mathematically. In this cooperative learning study, an environment conducive to group learning was noticed. Although all three members of this group wanted to learn math, each went about it in a different way. Placemat enabled the group members who originally had little in common to find some common traits that were shared among all three group members. This was the first step in providing a non-

threatening cooperative learning group environment. Numbered Heads would not be successful without the group members discussing each problem. They each must have been able to describe the correct process as well as get the correct answer in order for the group to earn extra-credit points. STAD was chosen to be used when the students were practicing geometric proofs. In this activity students were expected to talk to each other about the mathematics concepts learned. Proofs were difficult for students to master and STAD should have helped the students not only work on the proofs for mastery, but also help their fellow group members. By talking through the process, the students who helped other members also learned. The students who were being helped felt comfortable as they reviewed their own mistakes and talked about any errors or misconceptions. Extra-credit points on the test covering proofs were earned based on the average improvement of each individual team member.

The students were learning to use mathematical concepts to communicate ideas, show the process used in proofs, and enhance learning in the content area. This was a very important contribution of designing cooperative learning activities in the mathematics classroom, not only for communication, but also for facilitating the learning process and maximizing learning that would occur in the content area.

The researcher found it interesting to watch how the personalities of the students continued to surface during their discussions for Numbered Heads. The students were to complete each question on a worksheet that would later be used as a study guide for a test. Figure 5 presents a diagram that was used during a review worksheet during Numbered Heads.

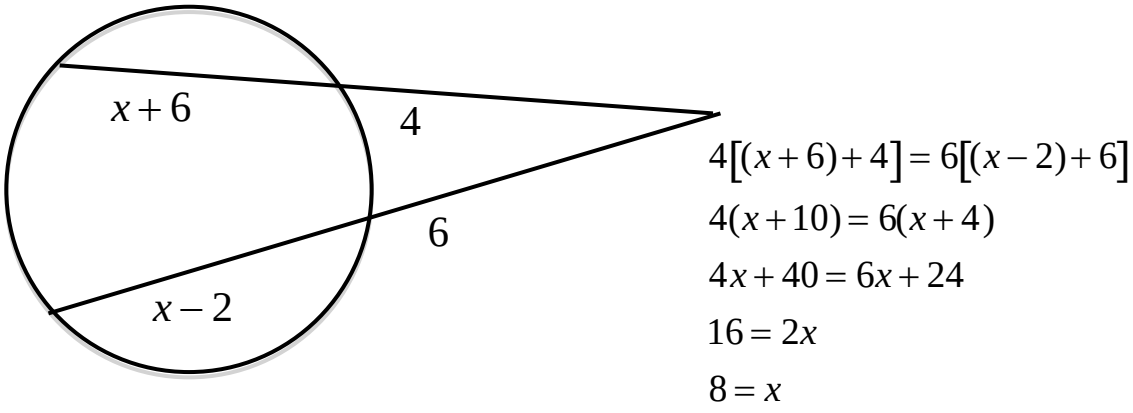


Figure 5. Diagram used in review worksheet during Numbered Heads

This example demonstrated geometric concepts involving segments of circles that extended beyond the circle. While Jeff was usually concerned with getting the correct answer any way he could, Mary understood each step and agreed, in order to move forward. One component of the facilitation of mathematics learning was peer coaching which involved talking about math and helping each other. The group members were responsible for making sure that each student not only understood the material, but could then explain it to the class. In order to accomplish this goal, the members needed to be able to communicate and keep others directed toward the assigned task. Each member functioned differently and compensated for others' weaknesses. Jeff's strength was in the content area; Mary was strong in organization and group regulation, and Heather played both roles when necessary. This enabled all members to learn from each others' strengths. In order for the students to be successful helping each other, they needed to have a successful method of student-student communication. Here, the members disagreed on the answer. In order to fulfill learning

the mathematical process, not just getting the answer, Mary redirects them to start over again.

H: I, I got 8.

M: What?

H: X = 8.

M: Uh, okay.

J: I got 4.8.

H: 4.8, that's not good.

M: Okay, let's start from the beginning, you guys.

H: Okay.

M: Okay, the top line. The whole is going to be X plus 6 plus 4. So 10 X plus 6 and then we have to multiply it by . . .

H: 10 X plus 6.

M: Yeah cause X plus 6 plus 4.

H: Oh that's . . .

M: Cause you do the whole thing.

H: Where are you getting this from? Are we doing the top one or the bottom one?

M: The top one. This one.

H: Okay.

M: Okay, oh yeah. So 10 X plus 6 and the . . .

H: Where are you getting the plus 6? Where are you getting 10 X plus 6?

J: Okay, I got 8.4.

M: See the whole line?

H: Yeah, I see the whole line.

M: X plus 6 is in the . . .

H: Got it.

M: This whole line is supposed to be this.

H: Yeah, yeah, okay, I know.

M: Plus this.

H: Yeah. Where are you getting 10 X?

M: Cause this is the whole line.

H: Where are you getting10 X? I see words.

J: Cause X . . .

M: But I don't see X and I see 6 and I see 4.

H: 8.4?

M: Cause you add these two together.

H: And you get 10 plus X, not 10 X plus 6.

M: Oh whoops. I thought that . . . I thought . . .

H: I'm like where are you getting 10 X?

M: No, I meant to say that. Sorry. You're like what? Wait, so 40, 40 . . .

J: Keep in mind that . . .

M: Yeah, I was like why are you . . .

J: It's the exterior times the whole thing.

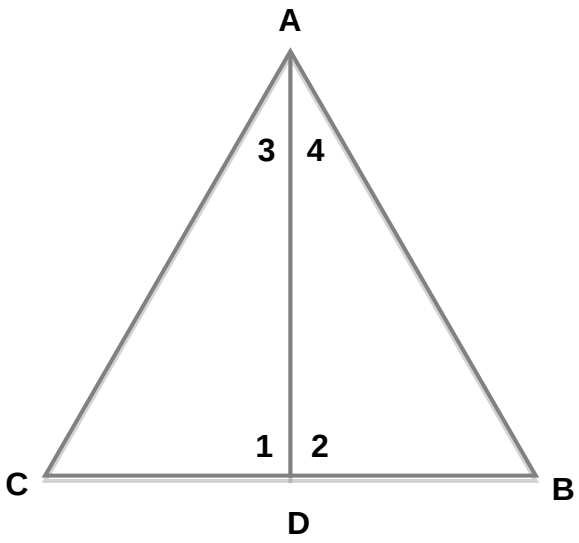
M: 40 plus 4 X, right? Right, right?

H: Right.

M: Okay.

Mary demonstrated her interest in getting answers from her fellow group members when she showed them what she was questioning in the illustration. This selection had a strong component of the facilitation of math learning because talking about math was evident. When students questioned each other, they showed a desire to truly understand the material rather than settle for a correct answer. When students were able to explain the process to another student, they had solidified the meaning for themselves. Student-to-student communication was an important aspect of cooperative learning. What was being communicated was the key to positive learning experiences and the mathematics thinking process.

Another example of the facilitation of the mathematics learning process occurred when the group worked on filling in the steps of a proof. In order to ensure positive interdependence, the group received one envelope that contained all of the steps of the proof on little slips of paper. The members were to organize the steps together and get that answer verified by the teacher before completing that proof on the study guide. A component of the facilitation of mathematics learning was providing an environment in which the students could freely talk mathematically. Immediately the researcher noticed that the group became more relaxed within the group setting when they finished each other's ideas. A free exchange of information, where everyone had something to contribute, evolved. In the STAD activity, the students were discussing the steps of a proof. The information that the students had prior to the discussion was shown in Figure 6, which follows.



Given: I$\triangle ABC$ with base BC;

AD $\perp$ bisector of CB

Prove: AD bisects $\angle$CAB

Figure 6. Proof used during STAD

This exchange of ideas showed how the group members talked about math in their relaxed learning environment by completing each other's thoughts.

M: Wait, which one do we want to start with, the given one?

J: We have to start with.

H: We don't have a given.

M: All right, so after that.

J: AD is . . .

M: Bisects.

H: So that means the two things are equal. If it bisects an angle.

J: Angle 3 is equal to angle 4 because….

H: I think it's this because it says it bisects.

J: This is the second to last.

H: It's an isosceles triangle so that means . . .

M: Because they have to be equal.

J: Yeah, that's the first one. Let's put that first.

M: AC equals AB.

H: And this has to be true too because it's a bisector of CB.

The students acted not as three separate members, but as one strong group concerned with completing the task and verifying each others' learning. This feeling of the strength of the group could not have been obtained without the group establishing that learning environment where they trusted each other. The communication segment showed the continuation of thought by the other group members. If the names were taken out, this passage could almost be spoken by one person. The communication that occurred previously allowed this transaction to take place. The group members encouraged each other and enjoyed the consensus that they were able to obtain. The group became so comfortable with each other that they were finishing each others' thoughts.

Summary

Three cooperative learning activities were selected by the teacher: Placemat, Numbered Heads, and STAD. Placemat is an activity designed to build team camaraderie, an important aspect of cooperative learning. Another aspect of Placemat is that it helped build a sense of comfort among group members and a sense of belonging (Kagan, 1994).

Numbered Heads was selected to strengthen several aspects of cooperative learning: the processing of information by students, communication within groups, the

development of critical thinking skills, and the process of reviewing material. Several cooperative learning skills, namely sharing information, listening, asking questions, summarizing, and talking quietly were addressed by this activity.

STAD required that the students complete tests individually, but they were responsible to ensure that their fellow group members mastered the material also. Based on the improvement points of each group member, extra-credit points were awarded to the group, thus using the reward system to solidify the idea of individual accountability.

Four themes emerged based on teacher observation, student journals and questionnaires, observer checklist and comments, as well as report cards and yearbooks. These themes were: change in attitude toward cooperative learning, the building of trust among group members, group regulation, and facilitation of math learning.

During this research, the three group members produced some surprising results in addition to findings that were consistent changes noted on the attitude questionnaires completed by the students prior to, and at the conclusion of, the cooperative learning activities. The findings indicated that there was a change in attitude toward cooperative learning. Also, the group demonstrated a gradual building of trust and finally showed several instances of group regulation.

The change in attitude was detected when comparing the attitude questionnaires. It was also verified in the journal entries of the students. The transcripts acknowledged that the students enjoyed the activities. Before beginning the cooperative learning study, students were unsure that anything good could come from group work. Placemat was the starting point of showing an attitude change. It was apparent that positive attitude changes resulted from students actually working together.

The trust-building was demonstrated when the students showed consensus on answers as well as process. The students encouraged each other and showed support for others' views. The examples where the members would finish each others' sentences showed the level of comfort and similar mindset that had developed. It was obvious that trust-building would not have taken place in a classroom without activities that forced students to cooperate.

Group regulation was essential for cooperative learning to be successful. Each member needed to see his/her strengths as well as weaknesses. The transcripts and processing forms demonstrated group regulation. Peer coaching and questioning were used. Heather and Mary took turns trying to keep the group directed toward the goal. It was evident that student collaboration contributed to their ability to self-regulate as a group.

Facilitation of math learning occurred when the group provided an environment in which learning could take place. The students were communicating mathematically when they talked through the process before arriving at an answer. Mary pushed this theory by showing her desire to understand the material, rather than just completing an assignment or getting the right answer. It was evident that student collaboration contributed to their ability to increase their learning about math as a group.

Positive attitude, trust-building, group regulation, and facilitation of math learning all played an important role to impact learning. Cooperative learning contributed to this role because the students learned better by working in groups; they established that bond through exploring and learning.

CHAPTER V

CASE STUDY: RED

Introduction

This chapter described and analyzed the data collected from the RED group in order to get a better understanding of the interaction in a cooperative learning setting. The chapter was divided into three sections: group profile, review of activities, and findings. The group profile described the personalities and showed the traits of each member. The same three activities that were used in the GREEN group were used for the RED group; all three activities were selected to engage students in cooperative learning. These activities were Placemat, Numbered Heads, and STAD. The data were compiled after analyzing transcripts of student discussions, observation checklists, and student notebooks that included journal entries, processing forms, and questionnaires. Four themes emerged from the data analysis: an attitude change toward cooperative learning, trust-building, group regulation, and facilitation of math learning. Although the interaction processes were different between the GREEN group and the RED group, there was an overall repetition of general themes. The data analysis focused on describing interaction patterns and student learning experiences in cooperative learning groups. The names of the participants have been changed to ensure confidentiality.

RED Group Profile

The RED group consisted of four members: Rick, Kara, Elise, and Brent. All four students had very little in common with each other beyond their participation in this study and being students in a regular level Geometry course. Three of the four students were sophomores.

Rick, the only freshman in the group, was very shy and excelled academically. His GPA was above 4.0. Rick participated in two different school choirs as well as an academic competition team. When asked to participate, Rick thought working in a group situation would be a "good thing" by allowing him to work with others and receive outside input. He had one reservation: this "good thing" would only be true if he had a good group. Rick was willing to help any member of the group, but initiated very few communication segments. A communication segment was an exchange of dialogue within a group. Rick began the following communication segment that produced input from every group member.

R: Did you get X equals 4?

B: Wait, wait.

E: Sixteen, that's what I got, 64 divided by 4

K: I got 16 = X

B: Oh well let's see. I subtracted negative 60, I mean I added 36 to both sides and I subtracted 6, oops, I see.

Kara was very popular and outgoing. She enjoyed spending time volunteering and helping wherever she could. She was an active member of VOFT (Volunteer Opportunities for Teens). Kara was determined to work her best in each class. Kara

earned predominantly B's on her report card, with a few A's in previous math classes. Math was her strongest class and she enjoyed math over other classes. Kara felt independent and believed that she could handle things on her own in math class. She accepted the role of self-appointed leader while trying to keep the group directed toward its goal. She was willing to try cooperative learning in order to improve her weaknesses. She was also looking forward to adding the knowledge of others to what she already knew.

Elise was shy and very soft-spoken. Although she was a good overall student (3.687 GPA), she never really found school activities that she enjoyed. She tried ski club, band, and office aide, but each involvement was relatively short-lived. She believed that she would be more likely to ask questions when in a small group. She also admitted that she did not like everyone in her group, but indicated she would work with them all.

Brent, the group member that Elise did not like, walked to the beat of a different drummer. He wanted to stand out and be his own person. He wore a trench coat all day every day. This isolated him from the average population and confined him to a very small group of friends. He was religious and enjoyed activities through his church. Brent struggled in math class as well as other classes. He experienced success while participating in band during high school. Brent tried hard, but got very frustrated when he did not understand the material. He thought cooperative learning would be a great learning experience if it were not a distraction from his learning. Although Brent thought he was engaged, the observers noticed him leafing through his notebook, looking at something else, staring off into space, being out of his desk, exhibiting

controlling behavior, looking disengaged, and doing his own thing. In addition to the transcripts, these observations were very helpful in giving the researcher a better understanding of Brent's behavior. It was now easier to understand why the group members did not think Brent was easy to work with in a group setting and did not feel that he was giving his best effort.

Although each group member had individual characteristics, they were able to work together as a group in order to reach the desired classroom outcomes. Each student brought unique characteristics that allowed the group to become that unique entity. Other than a few scattered marks for the other students, such as staring off or being disengaged, most of the negative behaviors noted by observers were associated with Brent. From the perspective of the researcher/teacher, Brent had a strong personality that was interpreted negatively by others; Brent's body language said 'Stay away!' One observer noted that Brent was disengaged during Placemat, the least challenging of the three cooperative learning activities. During the other two activities, which were more mathematically challenging, Brent's comments included "I can't do it," "I hate this," and "I don't understand figuring steps in a proof." The comments on the Individual Processing Forms indicated a notable disparity. Brent evaluated himself as excellent-to-good while his fellow group members marked good-to-OK for Brent.

The researcher was a little uneasy in anticipation of how this group would interact with Brent. Would they be patient enough with his questions and truly try to help him understand the material for the long term or just get him to complete the work for the time being? This group would put some of the components of cooperative learning to a true test.

Findings

When analyzing the data, four themes emerged. The research questions focused on the interaction patterns and student learning experiences during a cooperative learning activity. Four themes evolved during the examination of the data after reading and categorizing the data from different sources. The themes were positive attitude toward cooperative learning, trust-building within the group, group regulation, and facilitation of learning math, the same themes that emerged from data from the GREEN group. The group developed a level of trust that enabled them to share ideas without fear of ridicule. Group regulation was noted when the members helped each other and kept each other on task. There was evidence to support the facilitation of math learning when the students were able to communicate mathematically as they talked through the problems. The researcher focused on analyzing student interaction during the work in the three cooperative learning activities with the two-fold hope of identifying the process and characteristics of the interactions and learning about student experiences.

Attitude Change Toward Cooperative Learning

From the observations, student journals and questionnaires, and transcripts of student communications during each activity, it was noticeable that there was a change in attitude toward cooperative learning. In order for cooperative learning to be a success, students must believe that the group can be more successful than four individuals. Students' positive attitudes toward learning math were reflected in the transcripts, observation checklists, and students' notebooks that included journal questions, group processing forms, and questionnaires. Students not only showed a

positive attitude toward math, but in some instances showed a positive change in their overall attitudes. Although some students were apprehensive and unsure about the personal benefits of cooperative learning, they expressed enjoyment and enthusiasm toward cooperative learning and mathematics.

The teacher/researcher documented the attitude changes after their participation in the cooperative learning study when the students responded to the Math Attitude Questionnaires. There are three areas about working in groups where the researcher noted a change in attitude. For the first statement, *prefer working independently,* in the pre-, Elise was the only student who had no change. She answered "*disagree"* to this item both at the beginning and the end of the study. All the other three students changed their responses in the pre- and post- questionnaire. Rick changed his response from *agree* to *unsure*. Brent moved from *unsure* to *disagree*. Kara moved her response from *agree* all the way to *disagree*. Elise's response was a surprise to the teacher because of her quiet demeanor. An observer might view this as reluctance to work in a group. She responded that she liked pair work, just not group work. A change in response from the other three members demonstrated the change in attitude toward working in a group that cooperative learning can have.

In the next statement, *like working in groups*, Brent's response for both the pre- and post-test remained consistent at *agree*, while Elise, Rick, and Kara all changed their attitude from *unsure* to *agree*. In response to the last question, *will enjoy cooperative learning (enjoyed cooperative learning),* both Elise and Kara responded *agree* in the pre-Math Attitude Questionnaire, while Brent and Rick both responded *unsure*. These students changed their responses on post-questionnaire; all four students responded

agree. Table 4 describes the attitude changes according to pre- and post-Math Attitude Questionnaires.

Table 4. Attitude changes according to pre- and post-Math Attitude Questionnaires

		Agree	Unsure	Disagree
Prefer working independently	Pre-	R, K	B	E
	Post-		R	B, E, K
Like working in groups	Pre-	B	E, R, K	
	Post-	B, E, R, K		
Will enjoy cooperative learning (Enjoyed cooperative learning)	Pre-	E, K	B, R	
	Post-	B, R, E, K		

As a classroom teacher interested in solidifying the math content, the researcher noted several benefits that came from the changes of attitude. The students completed journal entries throughout the study, dealing with questions about the content. Two other journal entries were assigned at the beginning and end of the study. These entries dealt with cooperative learning. The students were asked about their previous cooperative learning experiences and their feelings about cooperative learning as they were beginning the study. Upon the conclusion of the study, the students were asked to describe their feelings about cooperative learning.

Kara documented in her original journal that "I usually don't like working in groups so this will be a new experience for me." At the end of the study, Kara showed her change in attitude by writing in her closing journal that she "…saw some benefits because they would know things that I didn't." Rick had previous cooperative learning experience in history class so he started the study with a good attitude. He noted, "I believe it is a good thing. You get to work with others and receive outside input. Others

can help you learn and you can help them." Rick also showed his hesitation when he noted that "it will only work with a good group." Upon the conclusion of the study, Rick noted in his journal that he liked it when his fellow group members would catch his mistakes. He also addressed Brent without directly naming names. He stated that "if there was someone in the group who wouldn't cooperate, this would bring down morale." Rick was able to work through this morale issue as noted when he wrote "cooperative learning was a good experience. I hope this is something that will continue in the future." Although Elise noted in her first journal about cooperative learning "I don't necessarily enjoy working with everyone in my group," her attitude seemed to change. In the final journal entry, she stated, "It was helpful to me because if I didn't understand something I would ask rather than never know how to do it." Brent enjoyed the whole experience although he got frustrated with proofs.

After completing the Placemat Activity, the members of the group each completed individual processing forms and together the group members completed a group processing form. The group noted they wanted to improve staying together and working together. Even more interesting, on his individual processing form, Brent felt particularly good about his group work. So the group thought they had problems working together, but Brent, who was the problem, thought he did a great job at that same aspect of group work.

The students also demonstrated a change in attitude while filling out individual processing forms after the activities. Group processing was a key element of cooperative learning. Group members must appreciate their strengths and notice their weaknesses. Processing forms helped students see the weaknesses and areas of concern

within group functioning. Although none of Brent's responses changed from one activity to the next, he did note that he thought his own contribution and cooperation were excellent; he also thought the group might view his cooperation as only good.

Table 5 included the answers that each student recorded on individual processing forms that were distributed and answered after Placemat and Numbered Heads. The questions were given to see how each student viewed his/her own cooperation and contribution in relation with how the group viewed each other's individual cooperation and contribution. The numbers represented self-report data from the processing forms. The students ranked certain areas using a Likert Scale with numbers from 1 to 5: 1 = excellent, 2 = good, 3 = OK, 4 = poor, and 5 = unacceptable.

Table 5. Contribution and cooperation according to processing forms

	B	E	R	K
My contribution	2-2	2-1	1-1	2-1
My cooperation	2-2	1-1	1-2	1-1
Group view of my cooperation	1-1	2-1	1-2	2-1

Elise and Kara noted that their contribution improved as their cooperative learning session continued. They also believed that other group members would agree. Rick felt his level of cooperation dropped off because he wasn't able to help everyone understand. He thought the group members would agree.

At the onset of the study, in addition to completing a beginning journal about previous cooperative learning experiences and feelings toward cooperative learning before the study began, the students also completed an attitude questionnaire. It was a

standardized questionnaire designed to analyze a person's possible success in a teamwork environment. The WORKING questionnaire was given in order to establish some patterns among the students' responses on different types of attitude questionnaires. In the questionnaire entitled WORKING, an item of interest was the students' responses to the question *like working in teams.* Brent responded *quite a bit*, Elise *almost never*, Rick *occasionally*, and Kara *almost never*. Elise was willing to work in teams but preferred pair work. Brent only saw cooperative learning as something with positive benefits.

Brent was the only one of the four students who was unsure about his own feelings related to working independently; Brent was the only one of the four students who liked group work. The other students viewed Brent as less than a perfect group member, but he viewed his attempts as *great*. For these reasons, even beyond his trench coat, Brent was unique among the members of the RED group. Although his attitude did not seem to change during the study, the students became more accepting of him and were able to work successfully as a group. The other three members were initially reluctant to work with Brent, but upon the conclusion of the study, they saw benefits to seeing others' opinions, including Brent's. Kara demonstrated her change in attitude toward Brent when she stated in her final journal entry that "it gets a little repetitive when one member always doesn't understand." She saw beyond that and ended with "My group, fortunately, worked together." She and her team were able to adjust their previous ideas about cooperative learning and appreciated each person's strengths and tried to help each other with their weaknesses. Brent stated that he was confused when Elise tried to organize the steps in a proof. When Kara offered to show her work to

Brent, he replied, “I don’t understand proofs.” Kara immediately supported Elise’s statement with a more detailed explanation of the thought process required for completion of the geometric proof.

Development of Trust

A major component of cooperative learning was trust-building. Trust-building included encouragement, group consensus, and mutual support. The trust-building was most evident when the group members began to open up to each other. Three of the four members were inherently quiet in the classroom setting. The trust that developed within the group began when Brent was able to tell the group that he was adopted and shared his religious beliefs. The trust was also demonstrated when the group members were not afraid to show their weakness with some of the math concepts. Each member felt safe enough to allow the group to help him/her through the concept. Group members felt safe making mistakes and exchanging ideas that may not have been correct.

A typical communication segment took place during the Placemat Activity when the group was listing positive adjectives. Religion was seldom discussed in a public school setting, especially in a math classroom. Brent was very religious and had no trouble sharing, however lightly, his ideas with the group. This segment was chosen to introduce Brent’s humor and religion.

R: Optimistic.

K: Oh yeah, like I can spell that. I’m thinking.

E: Considerate.

R: Compassionate.

B: Merciful, that's a religious term.

R: Loving, loving.

E: Kind.

The group took Brent for what he was and continued with the assignment of listing positive adjectives. Brent was probably smiling because he was being funny, but the group was concentrating on the ten positive adjectives.

It was easy to see the trust that developed within the group when adoption and grandparents were discussed in the following communication segments. First, Brent was not shy about telling the group he had been adopted.

B: Who here was adopted?

E: That's a good one.

When no one else agreed, Rick started to discuss his extended family. The reader must remember that these students were not from any similar circle of friends. Although the information they were sharing may not seem earth shattering, a certain level of trust needed to be developed before even this information could be shared without fear of it being used against them in the future.

R: Who here has their grandfather living with them?

B: Do you?

R: I do.

K: Really?

B: I have one grandparent.

K: I have three left.

B: Three parents or three pairs?

E: Three grandparents.

K: Three grandparents.

B: Okay.

Based on the transcripts and the amount of talk time, I would have expected Kara to be observed as controlling. She was expected to be a positive group member in order to be able to lead the group in such a way as not to appear controlling. It surprised me that the members were able to open up so easily about personal things like religion, families, and grades. This openness could not have been demonstrated unless trust-building had taken place within the group. The group members felt supported in their views, expressed interest in others' responses, and showed enough trust to share ideas.

The group members had such different personalities. Kara was the self-proclaimed group leader. Rick and Elise were quiet and would do their best to support the group. Brent had a great sense of humor, but that humor was often not understood. In the following segment, Brent was trying to be funny while combining one adjective with one uncommon commonality in order to get a group name. Elise didn't know him well enough and didn't understand his sense of humor.

R: Funny optimistic cat owners...

B: Which are we gonna use, cat owners?

R: I go with the cats cause that's just the most reasonable.

B: Or doesn't have brothers? Technically, since I'm religious, I have way too many brothers for my own good.

E: By brothers, we mean living in your house.

B: Okay. Hmm. Oh well, let's use the cats. I like the cats. Do we all agree on cats? Who agrees on cats?

One aspect of cooperative learning that was used during this study was teacher-assigned roles. These roles did not have a large impact on the communication segments, so they were not a major focus of the reporting, but Brent discussed his role quite a few times. According to the processing forms, Brent believed he was doing a great job as a group member and in his assigned role. His fellow group members felt quite differently throughout the study. They saw Brent as a hindrance to group work but did their best to keep the group working together. For the Numbered Heads activity, Brent was assigned the role of encourager. Here are two different instances where Brent mentions his role of encourager.

B: I am the encourager. Come on. Let's do this.

R: Good job.

And in this second example:

B: We are mathematical wizards. We can do this. How am I doing as the encourager?

R: I think you're doing a great job. I feel encouraged.

B: Do you?

R: Yes.

Brent was not usually encouraging, so this role may have helped him see this deficit and helped him improve it. The group members demonstrated interest in others' ideas by listening and responding to Brent.

Rick and Brent had this discussion that further shows the difference between how the two boys viewed proofs.

R: I love proofs.

B: I hate this.

R: I'm the encourager. I'm saying that to encourage everybody. I love proofs. We can do them.

Brent was able to give personal information about being adopted and was not hesitant to let the other group members know when he needed help or encouragement. Kara tried to keep the group on task and appreciated when the other students could help her with a concept that she didn't understand. Before this cooperative learning study, she preferred to work independently and felt successful when doing so. Elise showed an increase in cooperation and contribution while filling out the processing forms. Without the trust of her fellow group members, she would not feel confident enough to contribute fully to the group's desired outcomes. Rick was the only freshman and needed to trust the sophomores so he could help them without their getting upset that a younger student was better at math. He also opened up about his family situation when he shared that his grandfather lived with his family.

Group Regulation

The RED group demonstrated group regulation by peer coaching, questioning, monitoring the progress of the group to keep the group together and on task, and completing the assignment. Each member needed to be aware of areas of weakness and needed to work on correcting these in order for the group to function well. Students addressed group processing by completing processing forms after the activities. The students recorded and discussed what they did well, in addition to what they needed to work on. Together the group also filled out a group processing form that addressed similar questions. Although Brent was aware of his weaknesses in the content area, he was unaware of his weakness in the social aspect of the group. He thought everything went *great* from beginning to end concerning his cooperation and contribution. His fellow group members took this weakness, and although they got frustrated with him, continued to work with Brent to make him a positive member of the group.

Kara was monitoring the progress of the group. During Placemat, one example of Kara keeping the group working toward finding some commonalities was given in the excerpt. The examples below showed how Kara redirected the group when it seemed stuck or headed in the wrong direction. She initiated each conversation to press the group to a desired outcome. Kara was trying to get her fellow group members to think of a unique trait that only they shared but no other group shared. An example of the Placemat was given for the RED group.

K: What's a unique thing that we have?

R: You know that could cause arguments, anti-footballists, everyone will hate us.

B: Yeah, it also sounds contradictory, if you ask me.

R: The optimistic movie watchers.

B: I like cats. You know, if we use cats, we can't use funny and we can't use optimistic because that's a funny one. So we'd have to use funny.

R: We could have the optimistic cat owners.

K: That sounds fun.

Kara showed her personality as well as leadership by ending the segment on a positive note. The group found a name, but there was still time left in the class period. Kara pushed the group a little more. She was determined not only to complete the assignment, but also expected her fellow group members to excel when possible.

K: I think we can do better. Well . . .

R: Cats sounds good to me.

K: Yeah, like I am satisfied with it, but I think we can do better.

B: Yeah, I guess so.

K: We still have some time.

E: Yeah.

With the extra time and Kara's determination, the group kept trying to find another name. The group members finally found something they all had in common and Kara didn't even want to use it. Although Rick and Elise were satisfied with the commonality, Kara demonstrated her desire to do her best. She wanted to find something that students in other groups would think was interesting.

K: Who makes their bed in the morning?

E: No.

B: I don't make my bed in the morning.

R: I never make my bed.

B: Hey, something we all have in common.

K: Well, I don't want to write that down.

R: Might as well, it might be the one thing we all have in common no one else does.

E: No one else will think of it.

Evidence of positive interdependence was embedded within Numbered Heads by the following segments. The students were checking with their fellow group members for verification. One aspect of Numbered Heads was that the members of the group got extra credit points only if the person who was called on had the correct solution. This extra credit was then added to the total points earned during the quarter.

E: Did you get 16, 50, and 100?

R: Yeah.

K: Yeah.

B: The other side's 100. Those are equal . . . so AB is 130.

E: Wait, is it 96 or 196?

K: 196.

R: 196, yeah that's right.

B: What's the second one?

R: We don't know they are parallel yet, so we don't know they are equal.

K: Ah, true.

B: Angle X=Z.

K: So we should . . .

R: How do we know that X=Z?

E: Because if 1=2 . . .

R: Well, this would come next because we already know that they are equal because we have . . .

K: Side angle side. So triangle WXQ equals . . . is congruent to triangle WZQ.

One of the expectations of Numbered Heads was that everyone had the correct work, not just the correct answer. It made sense then that much of the conversation was directed at peer coaching and editing, as seen in the communication segment quoted above.

Although, according to the journals and processing forms, the group members struggled a bit with group cohesiveness, this was not apparent to an outside observer. They were able to hold together and concentrated on the activity at hand. That was a characteristic of a good group—one that can put their personal feelings aside and focus on the job and the outcome.

Facilitation of Mathematics Learning

In the RED group, students were able to communicate mathematically. They also had the desire to learn the material instead of copying the answers from their fellow group members. Brent had admitted he couldn't do the work on his own and wasn't willing to copy others' work. However, he did cooperate with his group and ultimately completed the assignments. A learning environment was established where students demonstrated the learning of math by talking mathematically. In this cooperative learning study, an environment conducive to group learning was noticed in the RED group.

The observer for the RED group during Placemat was the assistant principal. At first glance, there seemed to be an overwhelming number of negative behaviors that were observed. Placemat was chosen to allow the group members to get to know each other. This activity was non-academic and should have kept the members on task. One piece of paper was rotated and questions were directed toward the entire group in order to increase contribution. A checklist was filled out every two minutes with the behaviors of each student noted. The negative behaviors for listening were recorded for each of the members of the RED group. Examples of negative behaviors included leafing through notebook, looking at something else, and out of desk. It was not until these negative marks were more carefully analyzed that the researcher discovered why there were so many negative behaviors recorded. The behaviors were not out of the ordinary unless looking at one category: more than one person talking. For this particular activity, which was similar to brainstorming, one could expect more than one student to be talking at one time. These negative behaviors were understandable in the context of the Placemat activity. The observer also noted that the group was polite and responded when asked.

Effective mathematical communication was essential for cooperative learning to be successful. Although the RED group was not an ideal cooperative learning group, there was abundant math talk. In the following communication segment, which transpired during Numbered Heads, the group members were discussing the terms used in the equation and how they were related to the given picture.

B: What is this? Side times side?

K: Oh yeah, they want this times this equals this times this.

B: Oh, okay. That times that equals that times that.

E: The whole thing this plus this and then just this is equal to . . .

B: Equals that times that.

E: Yeah, equals this plus this, the whole.

B: Okay, I got it.

Although one topic was solidified, another unclear topic was soon discovered. During Numbered Heads, the students had to recall several topics from the chapter on circles in order to successfully complete a worksheet.

K: Wouldn't it be 16x plus 4 times 4?

R: You have to multiply x times 4.

K: x times 4, wait . . .

B: So it's x plus 6 times 10.

R: So 4 times x.

B: So it's x plus 6 times 10. Is that right? No.

K: 6 x plus.

A learning environment and a relaxed environment must be present for the components of cooperative learning to develop. Brent showed his determination to learn by questioning his group. He was immersed in a learning environment where students were helping each other and talking mathematically. Brent continued with a question addressing the equation.

B: Wait, I've got a question for you -- whole times exterior?

R: Yes, it's the whole line times just what's outside the circle.

B: Okay, so it's 4.

K: Okay, I get it now.

The learning environment of the RED group allowed each student to get his/her questions answered while discussing the questions in a mathematical way. The students discussed the properties of arcs, chords, segments, and line segments relating to circles. Math talk such as those examples was unique to the math class just as discussions about irony and alliteration would be unique to a language arts class.

The students were able to communicate mathematically while discussing a problem on circles. Few complete sentences occur, yet the communication was smooth and all members understood each other. A typical communication segment in the Numbered Heads activity would sound like this:

B: Then I am doing my job. What does "W" mean?

K: Whole, whole times exterior.

B: All right, let's say this. In fact, you already have that down.

E: Times it by 2.

B: Yeah, that's what I thought.

R: 10x – 6.

B: Multiply the bottom by 2.

Mathematical communication occurred and all students were involved. This talking math helped the students understand the concepts. By using the appropriate math terms, the students reinforced both their knowledge and understanding of the material.

STAD was used during geometric proofs. For some students proofs became a stumbling block that they could not overcome. Some students viewed proofs with the

same strong feelings they had for word problems. For these students, just the phrase "word problem," and now "proof," gave them negative feelings. The group needed to maintain the learning environment that had been previously established and not shut down when the academic difficulty increased. This was very evident in the next few communication segments that Brent initiated. The reader will get the sense that Brent was really struggling with proofs and was getting frustrated with proofs and himself. Brent stopped the discussion four times and finally ended the dialogue with his self-efficacy on proofs.

R: Should we put that all under one reason?

B: Wait, what's going on?

K: Angle 3 equals angle 4 because of definition of …

E: No, the same thing where you have angle 1 equals angle 2 ....

B: Wait.

K: Yeah.

E: We had given and then there was angle 1 equals angle 2 before KH and HK.

B: What?

E: Right there between those two stops.

B: I'm confused.

K: See how I'm doing mine?

B: I don't understand proofs.

Even though the group members were trying to be patient and talked Brent through the steps, the reader can feel the frustration that Brent was experiencing. This frustration was why cooperative learning, and specifically STAD, was chosen for use

with the section on proofs. As previously stated, many students experienced the frustration that Brent experienced and wanted to give up.

The following communication segment demonstrated how the students, Rick in this case, tended to talk out the steps.

R: Yeah, it looks to me like we need two angle bisector ones, because three and four also need to be equal, but we don't have enough.

K: Yeah.

R: But we don't have enough. This is gonna come last I know that.

The math communication took place between students and, as demonstrated above, by one person to himself just to clarify the steps of a proof.

When analyzing the data in STAD, many of the communication segments occurred with no response. Of those that had student-student interaction, Kara responded in most cases. Most of the time that a group member posed a question or made a statement, Kara commented on it. Considering she was not the one who excelled at proofs, this was a surprising statistic. Rick was the one who proclaimed to love proofs, but he was a quieter student.

Although the group members seemed to be communicating well, it did not appear to be even communication when progressing from Placemat to Numbered Heads to STAD. The subjects discussed were not as much on-topic and not as many students were involved in each conversation. When recalling why STAD was chosen, and because many students struggle with proofs, that was not such an alarming discovery. As the cooperative learning activities became more difficult, students experienced less self-confidence and more frustration as individuals. However, in each group, at least

one group member did understand the material and was able to lead the others successfully.

The observer for the RED group during the STAD activity was a biology teacher. She observed all of the group members looking at the speaker, looking at the example, and leaning in to show they were involved in the activity. The group members were also observed taking turns, looking at others' work, and showing group involvement.

Although Brent was observed with having a puzzled look, the observer noted this as a behavior that demonstrated that Brent was listening, even though he did not understand the concept. After reviewing the transcripts, the researcher agreed that Brent's facial expression was a reaction to the information being presented because he did not understand it. His puzzled look did not indicate that he was thinking about something else and not listening.

The only notes the observer wrote were that Kara seemed to take the lead. The observer did not imply this to be a negative thing; the notation was simply a statement. Math communication was evident from the transcripts and verified by the observations. The RED group members were able to provide an environment in which other members could discuss math topics easily.

Summary

Three cooperative learning activities were selected by the teacher: Placemat, Numbered Heads, and STAD. During Placemat, the students in the RED group learned some personal information about each other and what set their group apart from the rest in the class. Numbered Heads was an academic activity that allowed the group members to talk through the steps used to find unknowns in a circle. It was strongly based on formulas that the students were able to retrieve in order to help each other. STAD was used during the most challenging section, geometric proofs. STAD was used to verify the importance of individual accountability in cooperative learning.

Four themes emerged based on teacher observation, student journals and questionnaires, observer checklist and comments, as well as report cards and yearbooks. Although the general themes were the same as those in the GREEN group, individual differences emerged when analyzing the data. These themes were: change in attitude toward cooperative learning, the building of trust among group members, group regulation, and facilitation of math learning.

During this research, the four group members showed a change in attitude when they had a neutral view of cooperative learning that changed to one that viewed the experience as a positive one, one they looked forward to doing again.

The group showed trust when they listened to all views while discussing personal issues as well as mathematical issues. Each member was willing to share his/her differences and listen to the input from other members. Group regulation was noted when the students helped each other stay on task and discussed topics in which the group

excelled or needed additional work. Facilitation of math learning occurred when the students talked through the steps of a problem.

These themes were evident in both the GREEN and the RED groups. Cooperative learning provided a positive learning environment by enabling the group members to grow socially and mathematically. A closer comparison of the two groups is provided in Chapter VI.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Introduction

The job of math teachers has been to help students understand the material and make connections among various topics; that focus continues in today's math classrooms. For this understanding to take place, students should think mathematically and be able to communicate this mathematical thinking with other students and the teacher. During this study, groups of students in math classes used cooperative learning techniques to assist in student-student communication. The data from two groups were analyzed as a way to address two research questions: What were the interaction patterns within a cooperative learning group in a high school mathematics classroom? What were the student learning experiences while in these cooperative learning groups? Four themes emerged after analyzing the data. Chapter VI was the conclusion of the study and demonstrated how the interactive patterns led to math talk and learning. Final analysis of the data clearly showed that group members learned to communicate effectively in order to clarify and expand their math processing. The researcher noted that the data mirrored the expected positive outcomes of cooperative learning; the surprising absence of potential negative elements of group work was also noted. Chapter VI was divided into four sections: Discussion of Findings, Implications, Further Research, and Conclusions Drawn from the Study.

Discussion of Findings

The purpose of this section was to analyze, compare, and contrast the findings of two case studies. The cases were the RED and the GREEN cooperative learning groups. One advantage to cross-case analysis was that evidence based on multiple cases was more compelling to a reader than results based on a single case (Yin, 1994). This study looked at data through two research questions. These research questions addressed interaction of students while in a cooperative learning group. Because the activities that were chosen promoted student-student interaction, the study was naturally linked with fostering students' social skills (including communication, collaboration, problem-solving, and teamwork). Students needed these skills to be successful in the math classroom.

Miles and Huberman (1994) indicated that the identification of emergent themes could assist the reader when moving from descriptive data to the analysis of the meaning in the data. Themes with similar characteristics became evident across the cases. This study identified four emergent themes that were characteristics of cooperative learning: the change in attitude toward cooperative learning, the establishment of trust-building, evidence of group regulation, and facilitation of math learning. The study also showed evidence of essential cooperative skills: positive interdependence, individual accountability, face-to-face interaction, social skills, and group processing. Demonstration of these skills was necessary for each group to have a positive beneficial cooperative learning experience and insured the development of academic mathematic talk among students.

A case study design was employed to gain an in-depth understanding of the situation and meaning for those involved. The interest was in the process rather than the outcome, in context rather than a specific variable, in discovery rather than confirmation.

While the students worked in a cooperative learning setting, data were collected and analyzed during three activities: Placemat, Numbered Heads, and STAD. Although the same four themes emerged in both case groups, specific characteristics about and evidence to support each theme were different.

Placemat was chosen as the first activity because of the non-academic nature of the activity. This, along with the non-threatening nature of the activity, lent itself to a flowing discussion. The Placemat assignment was used in order to enable the group members to become familiar with each other and to establish a level of trust. The GREEN group had three members and was an honors level class; the RED group had four members and was a regular level class. The Placemat activity followed a Roundtable format that was described by Kagan (1994) as an extremely important cooperative learning structure used for teambuilding. Placemat occurred when students took turns contributing to the group in a written form. Typically in Roundtable, one piece of paper and one pen were rotated around the group. One student made a contribution and passed the paper and pen to the next student. The paper literally went around the table, thus the name: Roundtable. The structure of Roundtable was adjusted in this study. Instead of passing the pen along with the paper, the group members in this study each had a different colored marker. Placemat allowed students to build their team. The use of Roundtable enabled the researcher to see, with just a quick glance, the amount of contribution from each student. Due to this roundtable nature, the researcher

would have expected relatively equal participation. Since the activity was designed as a team-building, non-threatening, non-academic activity, it promised to produce a large amount of student-student communication. The students would not have needed the usual think time needed when solving problems in math. These activities produced a large amount of student-student communication.

Numbered Heads was chosen for the second activity in the data collection because of the high degree of positive interdependence it ensured. In this activity, in order for the group to be successful, each individual member of the group had to be successful. Kagan's (1994) Numbered Heads activity was used because of its marvelous way of producing positive interdependence, simultaneous interaction, and individual accountability. Only one student was responsible for the team's answer, but the students did not know who that would be until after the team had discussed the problem. The team was only rewarded if the student who was called on was correct.

STAD was chosen for the third activity for data collection because of the benefits it should have provided to the students working on the academically challenging section of geometric proofs. To help each team member, STAD used a reward system that was based on individual accountability. In STAD, the members were pushed to know the material themselves as well as be assured that their fellow group members knew it also. The individual student rewards were averaged before being distributed to each group member. The group would see the best reward when each member succeeded. The last lesson for data collection was a worksheet on proofs that was a piece of a larger data collection unit using STAD. STAD was used to motivate students to encourage and help each other master skills presented by the teacher. During the proof section, if students

wanted their team to earn team rewards, they had to help their fellow group members learn the material. Students discussed alternate solutions to problems, they helped each other past a stumbling block, and they even gave each other pointers on how to remember the next step. Although the students studied together, they took individual tests. Those scores were then used for the STAD reward system. As Barkley, Cross, and Major (2005) suggested, exercises in cooperative learning in the present study enhanced critical skills among students, including:

- using math talk
- explaining and understanding other perspectives
- discovering relationships
- organizing information
- developing strategies and analysis.

The current study also supported these outcomes relating student interaction patterns and student learning as shown in chapters IV and V, which discussed the specific data from both the RED and GREEN groups.

Attitude Change Toward Cooperative Learning

Both groups demonstrated a change in attitude toward cooperative learning. Although each member within the groups had slightly different responses, all members noted a positive change. The changes in students' attitudes were clear when responses from their journals and Math Attitude Questionnaires were compared. When the study was introduced, students were apprehensive about all of the elements that were required

of them. At the conclusion of this study, students' comments indicated a sense of enjoyment and a willingness to work on a team in the future. In the researcher's experience, students working with proofs had never before used the word "cool," as one student did in a journal entry.

In the GREEN group, a change to a more positive outcome occurred more often when completing the individual processing forms before and after the cooperative learning study. The journal entries also showed a change in attitude. If a student already had positive feelings toward cooperative learning, that student remained positive after the study. Jeff changed his journal entry from "I prefer to work independently with my strong subject, math" to "It helped me to work in teams." Heather was more neutral, but even her response became more positive. She adjusted her response from "I could live without the group work" to "I wouldn't mind doing it again." Mary had a positive attitude before and after cooperative learning.

The members of the RED group showed similar changes in both individual processing forms and journal entries. Originally, Brent stated that cooperative learning "can be a distraction from learning." At the conclusion of the study, he responded, "I enjoyed cooperative learning, but not proofs." Kara initially stated, "I'm more independent and like handling things myself," but concluded that "my group worked together and we all worked hard." Elise and Rick retained the positive feelings they had prior to the study.

The GREEN group showed a more drastic change when the members agreed that they preferred to work independently as the study began, but saw the benefits of group work as the study continued. The RED group members had more neutral feelings at the

beginning of the study. Their opinions changed, even though Brent was a challenge to the group's cohesiveness. Although Brent was oblivious to the idea that he may have been hampering the group from enjoying all of the benefits of cooperative learning, there seemed to be a positive attitude toward cooperative learning while the students continued to work in the group. According to Johnson and Johnson (1994), students' attitudes are changed primarily through personal relationships in groups, not the academic information that is obtained. This was certainly in evidence in this study.

Development of Trust

One primary reason for a group's success was the friendly atmosphere where each person felt safe. This was particularly important at the preliminary stages of a task when the group must to generate ideas; they must feel free to express ideas without fear of personal criticism (Blair, 2004). The students in this study developed that comfort level as the study progressed.

Trust was developed in both the GREEN and the RED groups. This trust was shown in several ways: the members were accepting of each other's differences, the group members shared consensus on an issue, the members shared ideas and were supportive of each other, and, finally, the members were interested in each other's responses.

Heather posed a question that she thought might bring out a common trait among the group members: their favorite subject. Instead, each member of the GREEN group had a different favorite subject. Jeff concluded the discussion by showing acceptance of everyone's different favorite subject.

The RED group members accepted Brent and his uniqueness when he would brag about his ability to be an effective encourager within the group. The other members of the group preferred to begin working on the assigned task, but they politely let Brent discuss his role in the group.

When a group reached consensus, a level of trust was developed that, despite all of their differences, allowed them to share this one event. Jeff was pleased to learn that his was not the only messy handwriting in the group, as demonstrated when Mary related to him that she was experiencing writing difficulty during that task.

The RED group members found very little in common, but they did uncover the fact that they all had cats. This common trait among the members of the RED group eventually became part of their group name: Optimistic Cat Owners.

Both groups demonstrated member support throughout the project. Several times, the GREEN group members showed support for Jeff by inviting him to join the triangle so they could work together. The RED group supported Brent when he became frustrated with proofs.

The GREEN group members accepted Jeff's differences and appreciated his mathematical knowledge. Mary carried on with the tasks at hand although she admitted that she needed the help from Heather and Jeff. Heather, accustomed to working independently, trusted Mary and Jeff to help her be successful in the math classroom.

Although the appearance of trust was different among the group members of the RED group, each member did show trust that was being developed during the study. The GREEN group developed trust also, but in a different way. The members of the GREEN group were more efficient at the skills needed to complete the assigned math

tasks. Their trust was shown when discussing the problems. The GREEN group members, who were accustomed to working alone and feeling that independence could have been the best way to work on math, began to open up to each other. The RED group members also learned to work together but needed each other's help more in order to have success in the math classroom. They built trust by opening themselves to making errors. In order to coordinate efforts to achieve mutual goals, individuals must know and trust each other, communicate accurately, accept and support each other (Johnson, 1993, 2003; Johnson and Johnson, 1994). The task of creating and maintaining collaborative environments that involve trust requires honest communication (Hulse-Killacky, Killacky, and Donigian, 2001). It can be said, given the analysis of communication in this study, that students achieved a certain level of trust.

Group Regulation

Helping one's group to reach its goal seems to be highly motivating; after students realize that they are all needed, they seem willing to make the effort (Davidson, 1990).

In addition to the fact that the group only had three members, the group had Mary, a person who consistently strove to be a positive role model for everyone. Her sensitivity toward students with special needs was based on her relationship with her older brother, who was also a student with special needs. One of the results of her sensitivity was that she did not want to let Jeff ever waste time. When the discussion stalled, Mary prodded Jeff to see if he could find a common trait among the group members, so he started talking about Canada. As he began to wander off-task, Mary

redirected Jeff to write something down and asked the group a new question. Mary began a new topic before Jeff could, in her mind, get too far from the assigned task, which was to find common traits among group members. Similarly, the members of the RED group also reminded each other to stay on-task. Surprisingly, within well-structured cooperative learning groups, students rarely make negative comments to each other or discuss topics unrelated to their task (Davidson, 1990). This was true in the present study.

Until the STAD activity, the GREEN group members did a great job working together despite Jeff's very strong feelings of not wanting to cooperate.

The group members who led the most communication segments were Mary and Brent. This was predictable for the GREEN group because research suggested that the strongest math student (Mary) would lead the conversation. In the RED group, however, Brent was not the strongest math student, though he believed that the others were interested in everything he had to say. As research has shown, the ability to adjust one's behavior to work effectively with others and to communicate with others can be learned only in the process of working and interacting with others (Kagan, 1994).

Mary was constantly in charge of keeping her group together, on-task, and giving their all. They were all very good students, but this separated her on certain tasks.

The number of communication segments dropped as the academic level increased. Again, this was not a surprise because proofs were so difficult and required more thought time. There was also more discussion with the teacher because the students asked for verification and had to get new problems. These discussions were neither coded nor used for this analysis. Social and academic goals are closely linked (Gillies

and Ashman, 2003). The students in this study showed evidence that supported this statement; social outcomes extended beyond the classroom.

Structuring math lessons cooperatively ensures that students learn from each other's points of view and give and receive support from classmates.

Facilitation of Mathematics Learning

Cooperative learning promotes higher-quality reasoning strategies and the ability to transfer math strategies from problems completed during group work to problems completed individually. Davidson (1990) maintained that cooperative learning aids the students in correctly completing math problems while mastering math knowledge.

Before the incorporation of cooperative learning into the math classroom in this study, students thought talking math meant comparing the answers on an assignment. During and after the study, the students began to view math talk quite differently. They would use terms that were content specific and use algorithms to discuss a problem instead of just giving the final answer. This change in interaction was a direct result of the cooperative learning techniques and activities.

The GREEN group and the RED group were similar in that they each had a member who made the math learning different or unique. Although each group had that special scenario, its origin was quite different. Both Jeff (GREEN) and Brent (RED) had poor social skills. Jeff's were related to the diagnosis of Asperger's Syndrome; one of the components was poor social skills. His fellow group members, Mary and Heather, helped him learn how to be a member of the group and listened as he practiced talking math. When completing the Numbered Heads activity, Jeff was content with using the

solver key on the calculator to get the answer. In his opinion, he talked math by telling his group members how to complete the correct key sequence. Mary and Heather tried to remind Jeff that they needed to work through the process using the formulas for circles from the lesson. As Jeff became more familiar with his group members, his talking became more academic. Jeff became a leader during STAD and, instead of giving his group members the answers to the proofs, he presented one step at a time and waited for clarification. He began one communication segment by stating, "Okay, the first one is…ABC," and another by stating, "We have to start with…"

Brent was a social outcast. He was unaware of his inability to communicate, both mathematically and non-mathematically, with his peers. His fellow group members were very patient and helped Brent work through his frustration, especially with proofs. During Placemat, Brent was trying, in his own way, to help his group find issues that bonded them together. His statement was "Who here believes that having school spirit is treason?" He did not understand that anyone would not be able to follow his reasoning and reach his conclusion. Although Brent was very frustrated with the proofs used during STAD, he was trying to use the math terms when he suggested, "…we have to use AAS." This use of math vocabulary was one example of how Brent was able to overcome at least one of his hurdles in math class. Both Jeff and Brent helped their group members learn the material better by enabling them to understand the process well enough to be able to explain it; they became peer tutors.

When looking at the discussion that actually took place while the students were in the cooperative learning groups, talking out loud seemed to appear often while the students were discussing proofs. Proofs contained a series of steps, not a specific

algorithm that led the students to an end result. A great deal of discussion took place when the students viewed an alternate method of arriving at the conclusion.

The level and kind of participation changed because of the nature of the activities. The activities in this study progressed in amount and level of academic difficulty, so students who were outgoing, but poor in math, might have quieted down. The stronger math student might have taken over the conversation. On the other hand, the outgoing student might have still controlled the conversation, if that student asked questions as needed.

Although Brent was not the strongest student academically, he still strove to understand the concepts. It was evident that much of his frustration with the lesson at hand stemmed from not knowing material from previous classes. Brent was absent quite a bit and was usually negligent about completing work he missed, whether that included written work or memorization. Since he either missed lessons or wasn't paying attention, Brent didn't know what variables meant in equations or what form answers should take. Even though Brent (one group member) fell behind temporarily, everyone benefited because his fellow group members helped him get caught up.

The conversation leaders were Mary and Rick. Mary was not a surprise, because although all students in the GREEN group were strong in math, Mary was the one who was the conversationalist, the one who kept the group going. Rick was a strong math student, so that was understandable, but Brent was in second place. He struggled with math, so one would wonder in what direction his communication segments would go. Rick often knew the answer but encouraged his fellow group members to find the answers without being told directly.

Brent showed that his communication was not because he was a leader in the group; quite the opposite was true when it came to proofs. On several occasions near the beginning of class, Brent asked the group what was going on or asked for clarification. He didn't want to slow the group down any more, so he started trying to work on his own. When this proved too much for him, Brent responded by saying, "I hate this."

Before the study, this researcher noticed (a) that upper-level math students preferred to work independently rather than being slowed down by working with any other student; and (b) that lower-level students preferred to work independently rather than exposing their ineptitudes to classmates. This study showed that students of each level worked cooperatively in a group and benefited from that group work. The students were increasingly more willing to accept cooperative learning and this teamwork facilitated the completion of in-class assignments. Cooperative behavior is associated positively with academic success (Gillies and Ashman, 2003). The results of this study verify that statement.

Like the Barkley, Cross, and Major study (2005) in which children used discussion to support the mathematical learning of teammates through the development and sharing of their own mathematical thinking, while listening to the mathematical ideas of others and restating them in their own words, this study is a testimony to ways students ask questions about and provide insights into the mathematical ideas of others using cooperative learning. Students acquired math skills by thinking and talking math with their group members. They learned to understand concepts by sharing ideas with others.

Implications

The researcher noticed that the benefits from cooperative learning were shown by students of varying abilities and personalities; this was, and continues to be, a desire of math teachers. This advantage reinforced the idea that cooperative learning was beneficial in the classroom. The researcher selected three students to demonstrate the uniqueness that was present in each student and how each student worked in a cooperative learning group. The chosen activities and instructional approaches worked across different groups and also worked with students who were very different. After analyzing the data, Jeff, Mary, and Brent were chosen as representatives of the differences among students who participated in the study; examples from the transcripts submitted validate these choices. Jeff was chosen because of his Aspergers diagnosis, where a common trait is the inability to socialize with peers appropriately. Mary was chosen because of her obvious patience, nurturing, encouragement, and ability to keep her group on task, especially Jeff. Brent was chosen because of his anti-social behavior. Originally the researcher thought Jeff and Brent would not gain the benefits of cooperative learning because of their temperaments, but structured cooperative learning was obviously beneficial to both students.

Academic goals rank high on the priority list of high school mathematics teachers. Social goals and academic goals can be accomplished simultaneously. Working as part of a cooperative team enables an individual to make friends and avoid isolation. High school students value making friends and being responsible to others, often even more than the pursuit of academic goals (Blair, 2004). A result of this study was verification of Blair's research. From the results of Numbered Heads and STAD, the

teacher/researcher noted the accomplishment of academic goals; data from the study clearly showed the students' achievement of positive social goals. Therefore, this study demonstrated a win-win situation for both teachers and students.

In this study, small group learning offered opportunities for each student to become an active participant. Each student had a variety of skills to bring to group work. The effective instructor must be aware of how each group is functioning and must also support each student's active participation. Rogers, Reynolds, Davidson, and Thomas (2001) noted the following student characteristics that are addressed by group work.

- One student might perform basic computations quickly while another student might easily understand a new idea.
- One student might be comfortable with a calculator or computer while another excelled at reading.
- One student who struggled to get started could often complete a problem once he began; another student might have no trouble completing the first step.
- The student who was quick and usually accurate might struggle to verify his own work; but the slower student who questioned the process might help to find errors in the quick solution.

When a cooperative learning group functions correctly, students learn to identify and integrate their varied skills. This was apparent in the current study when, for example, Mary's communication skills and Jeff's strong math skills combined to facilitate learning for all the group members.

In some cases, cooperative learning groups will not only improve social skills in students with Aspergers, but also allow the child to exhibit his abilities in certain subjects. Teachers must continue to monitor the behavior of the student with Aspergers and his peers (Aspergers and classroom accomodations). It is when students with disabilities are liked and accepted that inclusion becomes a positive influence on the lives of students with and without disabilities (Johnson and Johnson, 1994). Mary and Jeff demonstrated this positive exchange.

The instructional procedures needed for the constructive inclusion of students with disabilities benefit other students as well: the shy student, the over-aggressive student, the bright but stereotyped student, and the average. All students need to be accepted and benefit from a classroom where it is acceptable to be different. Research has shown that when students without disabilities work with their peers who have disabilities, the result is increased empathy and an ability to view situations from a variety of perspectives (Johnson and Johnson, 1994).

Most of the responses from Jeff were short or one-word responses such as: yeah, okay, Catholic, I do, no, some of it. These were his answers in six different scenarios. In addition to his lack of expounding, Jeff had a hard time carrying on a normal conversation. In addition, Jeff's short answers did not invite further information from his fellow group members. In general, Heather tolerated him and Mary tried to get him back on-task. Neither group member passed judgment on Jeff while they tried to communicate. Jeff, who preferred to do everything by himself, began to open up during Numbered Heads. He was willing to ask for help, an unusual occurrence, when he didn't agree with his group members' answers. When this research began, he indicated

'unsure' as his attitude toward group work; at the end, he said his attitude was 'agree;' those responses demonstrate a significant change. Though he appeared to be socially awkward, the raw number of times Jeff initiated communication segments increased as the cooperative learning study progressed. Jeff liked proofs, which were the basis of the STAD activity, and began to speak to his group with confidence. He was confident in his math ability and grew comfortable with his group members. Whether he felt more comfortable within his group, the group work, or the material, cooperative learning produced a positive impact on Jeff. A student that was first interested only in his own work and benefit became one who was able to overcome his social awkwardness and enjoy the camaraderie of the group. This experience will benefit Jeff beyond his scholastic endeavors.

It is peers without disabilities who provide students with disabilities entry into the typical life experiences of their age groups, such as going to dances, taking buses, going to movies, shopping and knowing what is cool and what is not (Johnson and Johnson, 1994). Mary gave Jeff that normalcy he needed in the classroom setting.

In contrast to Jeff's social awkwardness, Mary enjoyed working in groups and always tried to get or keep her group members involved in the activity; her personality was nurturing and sincere. Most of her responses looked more like: Have you? Fun? Are you really? She showed consistent interest in responses from her fellow group members. Mary demonstrated her nurturing skills by getting Jeff involved and keeping her group focused on its task. When Mary discussed transferring what happened in math class to her oxymoron sheet, she showed that she was a good student and that she carried her math lesson into her English lesson. A good student across the curriculum, Mary's

interactions remained consistent; she initiated about half of the group's communication segments. Even during a conversation in math class, Mary showed her polite demeanor while still taking care of Jeff. She thanked her group members when they helped her and would often end her communication segments by asking if they were okay. She verified that they were in agreement and ready to move on. Mary wanted the group to wait until she was ready. She did not want to copy what someone else had; she really wanted to try to help the group figure it out together. As personified by Mary, a cooperative learning group leader is expected to keep each group member involved and on-task as they work toward the desired goal. As a result, all students benefit academically and socially.

Within cooperative groups, students receive considerable encouragement and support in their efforts to learn mathematical processes, strategies, and concepts. Brent demonstrated this need during the cooperative learning exercises, especially with proofs.

At the onset of the Placemat activity, Brent pointed out to his group that he thought they should work on being a more social group. Brent, in line with his friendly personality, wanted to have fun during the Placemat activity. During Numbered Heads, Brent really just wanted to comprehend the material when it was at a level that he could understand. He was not afraid to ask his group members to slow down until he understood. Brent was doing what he thought was correct, but he didn't fully understand the formulas. He would suggest a method with confidence, until he was politely corrected. Brent was often confused, but he had good fellow group members who were patient and willing to help. At the beginning of STAD, Brent tried to understand what was going on. In several different situations, he responded to the group with confusion

and frustration. He stated outwardly that he didn't understand proofs. He claimed that he did not even understand what he was doing. He felt the need to contribute to the group but had no sense of what was reasonable to say. He, instead, began sentences, but relied on his fellow group members to fill in the missing pieces. An element of Brent's difficulties during STAD was his absence, combined with his lack of paying attention, when the bases for the activity were explored during previous classes. Brent's interactions changed by becoming more negative; he initiated fewer communication segments during the study of more difficult material.

Although the personalities of each participant were distinct, the results of their efforts in the cooperative learning groups led to common patterns with positive results; Jeff, Mary, and Brent each benefited from cooperative learning. These three students were examples of atypical high school students; students with special needs, extreme patience, and inability to fit in socially. If such diverse students benefited, then it would seem appropriate to say that all students should benefit from cooperative learning. Even students with different modes of learning should develop the abilities to stay on-task and to contribute a fair, though not necessarily equal, amount of interaction based on individual competency. And, finally, although the study did not allow for generalizing, students who had developed a fear of math found that cooperative learning lessened their fear.

Further Research

The current study investigated cooperative learning as a technique to develop cooperation and teamwork among high school math students. During this research,

several areas for further study arose, including two that have implications for a deeper understanding of cooperative learning in the math classroom: (a) group size and (b) the power of Roundtable, both as an introductory technique and as a method to develop teamwork. Group size was relevant to findings in that smaller groups (2-3 members) offered different opportunities for dialogue and its resulting implications for teamwork. The power of Roundtable as a written process was exemplified when group members paid attention to a comment that had been previously ignored or overlooked.

All students need extensive experience listening to speaking about, reflecting on, and demonstrating mathematical ideas. Active student participation in learning through individual and small-group explorations provides multiple opportunities for discussion, questioning, listening, and summarizing. Using such techniques, teachers are able to direct instruction away from a focus on recall toward a deeper conceptual understanding of mathematics. It is equally important that students be able to describe how they reach an answer or the difficulties they encountered while trying to solve a problem (NCTM, 2000).

The National Council of Teachers of Mathematics (2000) suggested the use of small groups in addition to other instructional methods in mathematics classrooms to help attain the major curriculum standards that focus on problem-solving, reasoning, communication, and making mathematical connections. As students verbalize, they learn to use correctly the necessary academic language correctly (Kagan, 2009).

If, in the future, this researcher were to study communication and teamwork in a classroom setting, the following ideas would be carefully considered. First, should the study include an equal number of same-level classes in order to clarify any questions

about similarities and differences between discussions in the two levels? Second, should all groups consist of four students? Third, when a class roster does not allow for all groups to have four members, what are the ramifications of other-sized groups? Finally, even when groups of four are formed, what changes occur in the case of an absence?

Although this study was not generalizable, it was a beginning look at the interaction patterns in a high school math classroom. How the interaction of students changed during the participation in three cooperative learning activities is of importance to the learning that takes place in that high school math classroom. The extent of student discussion is a good indicator of the level of learning. A good rule of thumb is that more discussion about mathematics means more learning (Davidson, 1990). To promote math education, all math teachers should use cooperative learning.

For individuals to learn and adopt the necessary skills and strategies, they must be educated in instructional settings that encourage investigation, cooperation, and communication (NCTM, 2000).

In each case in the present study, group interaction enhanced students' attitudes toward cooperative learning, enabled the development of trust, revealed group regulation, facilitated math learning, and strengthened communication. In order for this to happen in classrooms across the nation, there must be more staff development to prepare teachers to use cooperative learning techniques.

Conclusions Drawn From the Study

The purpose of this multiple case study was to explore interaction among students in cooperative learning groups in two high school mathematics classes. The research questions allowed for the construction of the study. Three cooperative learning

activities were used to analyze the differences in the interaction as the activities increased in amount of academic rigor. Four major themes emerged. The themes were: change in attitude toward cooperative learning, development of trust, group regulation, and facilitation of math learning. All four themes were examined; they emerged in each case. The analysis of participants' individual interactions allowed for similarities and differences among students and groups to be illustrated. The group composition was different from the GREEN to the RED group, yet similar interaction occurred. By allowing students to work cooperatively, peer tutoring, math communication, and facilitation of learning were supported. Cooperative learning showed an increase in the above components for students of different levels, personalities, and family backgrounds. To enhance student learning and communication, cooperative learning techniques should be employed. These cooperative learning sessions were instrumental in creating a healthy learning environment, which is desired by all math teachers.

While working as teams, the students completed each of the three required in-class assignments. The Placemat activity led to an increased familiarity with each other as they identified similarities among the members of their own group; completion of this activity meant that each group found its own unique identity and, using that identity, found a name for the group. As each group worked on the Numbered Heads activity, students participated toward the team's goal of checking the correctness of each other's computations; accurate completion of each problem was required for the chance to earn extra credit. The completion of the STAD assignment was important to each student because grades were a combination of individual scores and group improvement.

Math talk facilitates the learning of math. The NCTM Standards (2000) emphasized the importance of developing mathematical language and communication in order to understand concepts. The dialogue that takes place helps everyone understand math concepts more deeply as well as helping children increase their competence in using mathematical language. Children gain greater understanding and ownership of mathematical concepts as they develop and express their own ideas. Describing methods to group members can clarify a student's own thinking. Math talk provides opportunities for children to understand errors they have made. By building understanding, math talk also prepares children for test items that require explaining an answer. Those concepts were directly connected to this study's research questions, which related to the interaction patterns and learning experiences in cooperative learning groups.

A good give-and-take discussion can produce unmatched learning experiences as students articulate their ideas, respond to their classmates' points, and develop skills in supporting their positions (Davis, 1993). In cooperative learning groups, students are provided the opportunity and the successful experience for intrinsic motivation to discuss, explain, and elaborate what is being learned, all of which increases students' ability to communicate mathematically. Interaction patterns observed in this study echoed the anticipated outcomes as described in earlier research.

The literature for ESL and online classrooms showed how students help each other; this study added the high school math classroom to that base of research. Although mathematics was the primary goal of the classroom, not interaction or communication, students must still be able to communicate. This study was a starting point for interaction. It showed that student talk enabled students to be more successful

in the math classroom. This study showed that communication happened and it was productive communication.

Student interaction was vital to the success of cooperative learning. As the activities employed in this study were completed, students' conversations indicated an increasingly relaxed atmosphere among classmates who typically had nothing in common prior to the cooperative learning experience. Numbered Heads required completion of the assignment so that every student understood and could explain the process for solving the assigned problem. Because a student would be selected randomly to explain the problem, every student was expected to be prepared. In order to complete STAD, students were required to finish one set of instructions before they were given the next information. Therefore, in-class teamwork was vital. As the activities became more challenging, student interaction changed, though the underlying trust gained during earlier activities still remained.

The researcher found a method that positively changed students' attitudes toward cooperative learning, developed trust, improved group regulation, and facilitated math learning. This strong desire of math teachers now has evidence to support those desires. Math teachers who plan to implement cooperative learning should understand that the positive results of this study may be related to the relationship that had been established between the teacher and the students during the first three-fourths of the academic year which preceded the beginning of this study.

When students interact, they observe, imitate, and build on each other; they experience the encouragement, support, warmth, and approval of their fellow group members; they have peers evaluate and give feedback; they teach peers; they are

exposed to different strategies; and they have classmates encourage them to complete the task (Davidson, 1990).

As presented in this study, math instruction will help students think mathematically, understand connections, and use math knowledge, if cooperative learning is employed in the math classroom for the following reasons:

- Cooperative learning a change in attitude toward group work.
- Cooperative learning promotes the development of trust.
- While working in cooperative groups, the members learn how to regulate the group.
- Cooperative learning enables the facilitation of math learning.

An extensive body of research emphasizes student-student interaction as vital to enhancing student academic and personal development (Reddish, 2000). Active learning requires intellectual challenge and curiosity, which are best aroused in discussions with other students. Explaining reasoning strategies and analyses of problems to classmates often results in discovering insights, using higher-level reasoning strategies, and engaging in metacognitive thought. Such discussion requires students to use the language of math and demonstrate their mathematical reasoning to others (Davidson, 1994).

The data on cooperative learning, including the study presented here, indicate that in order to become confident and successful mathematical problem-solvers, students need to work cooperatively with others.

When students have learned to work cooperatively, in the complete sense of that experience, teachers should respond by incorporating cooperative learning activities into

numerous academic settings. Then both teachers and students will achieve meaningful educational goals.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

Office of Research Services and Sponsored Programs
Akron, OH 44325-2102
(330) 972-7666 Office
(330) 972-6281 Fax

February 27, 2003

Susan R. Phillips
1325 Chantilly Cr.
North Canton, Ohio 44721

Dear Ms. Phillips:

The University of Akron's Institutional Review Board for the Protection of Human Subjects (IRB) completed a review of the protocol entitled *"Cooperative Learning: Student Discussions in a High School Mathematics Classroom"*.

The protocol qualified for Expedited Review and was approved on **February 26, 2003.** The protocol represented minimal risk to subjects. Additionally, the protocol matched the following federal category for expedited review:

> *collection of voice, video, digital, or image recordings made for research purposes*
>
> *research involving materials (data, documents, records, or specimens) that have been collected or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis)*

This approval is valid for up to one year from the approval date or until modifications are proposed to the project protocol, whichever may occur first. In either instance, an Application for Continuing Review must be completed and submitted to the IRB.

Please note that within one month of the expiration date of this approval, the IRB will forward an annual review reminder notice to you by email, as a courtesy. **Nevertheless, please note that it is your responsibility as principal investigator to remember the renewal date of your protocol's review.**

Please retain this letter for your files. If the research is being conducted for a master's thesis or doctoral dissertation, you must file a copy of this letter with the thesis or dissertation.

Sincerely,

N. Margaret Wineman

N. Margaret Wineman, Ph.D., IRB Chairperson

Assigned Research # 20030225

Cc: Susan Olson, Department Chair
Lynne Pachnowski, Advisor

Office of Research Services and Sponsored Programs
Akron, OH 44325-2102
(330) 972-7666 Office
(330) 972-6281 Fax

January 5, 2004

Susan Phillips
1325 Chantilly Circle
North Canton, Ohio 44721

Dear Ms. Phillips:

The University of Akron's Institutional Review Board for the Protection of Human Subjects (IRB) completed a review of the protocol entitled *"Cooperative Learning: Student Discussions in a High School Mathematics Classroom"*. The IRB application number assigned to this project is **20030225-2.**

The protocol qualified for Expedited Review and was approved on December 30, 2003. The protocol matched the following federal category for expedited review:

> *continuing review of research previously approved by the convened IRB as follows: (a) where (i) the research is permanently closed to the enrollment of new subjects; (ii) all subjects have completed all research-related interventions; and (iii) the research remains active only for long-term follow-up of subjects; or (b) where no subjects have been enrolled and no additional risks have been identified; or* ***(c) where the remaining research activities are limited to data analysis***

This approval is valid until February 25, 2005 or until modifications are proposed to the project protocol, whichever may occur first. In either instance, an Application for Continuing Review must be completed and submitted to the IRB.

Please note that within one month of the expiration date of this approval, the IRB will forward an annual review reminder notice to you by email, as a courtesy. **Nevertheless, please note that it is your responsibility as principal investigator to remember the renewal date of your protocol's review.**

Please retain this letter for your files. If the research is being conducted for a master's thesis or doctoral dissertation, you must file a copy of this letter with the thesis or dissertation.

Sincerely,

Sharon McWhorter, Associate Director
Research Services and Sponsored Programs

Cc: Susan Olson, Department Chair
Lynne Pachnowski, Advisor
John Queener, IRB Vice Chair
Phil Allen, IRB Chair

APPENDIX B

PROJECT DESCRIPTION

PROJECT DESCRIPTION FOR THE INSTITUTIONAL REVIEW BOARD

Cooperative Learning: Student Discussions in a High School Mathematics Classroom

Purpose of the study

The NCTM (National Council for Teachers of Mathematics) supports the assumption that it is no longer sufficient for high school mathematics teachers to use only one instructional method (2000). According to the US Department of Labor, who surveyed Fortune 500 firms, the workplace basics are: teamwork, problem solving, interpersonal skills, oral communication, and listening (Baloche, 1998). According to a study by the American Assembly of Collegiate Schools of Business (AACSB) (2002), organizations have found that many of today's graduates are not acquiring a team-centered approach to problem solving. Businesses want employees who can communicate and work as a team. We, as educators, should incorporate this into our curricula. This study proposes to investigate one type of curriculum that will address this question. A content analysis will be performed on the discussions taped during cooperative learning activities in a high school mathematics classroom. This content analysis will examine the efficacy of cooperative learning as it relates to teamwork issues, specifically listening, positive talk, and role-playing.

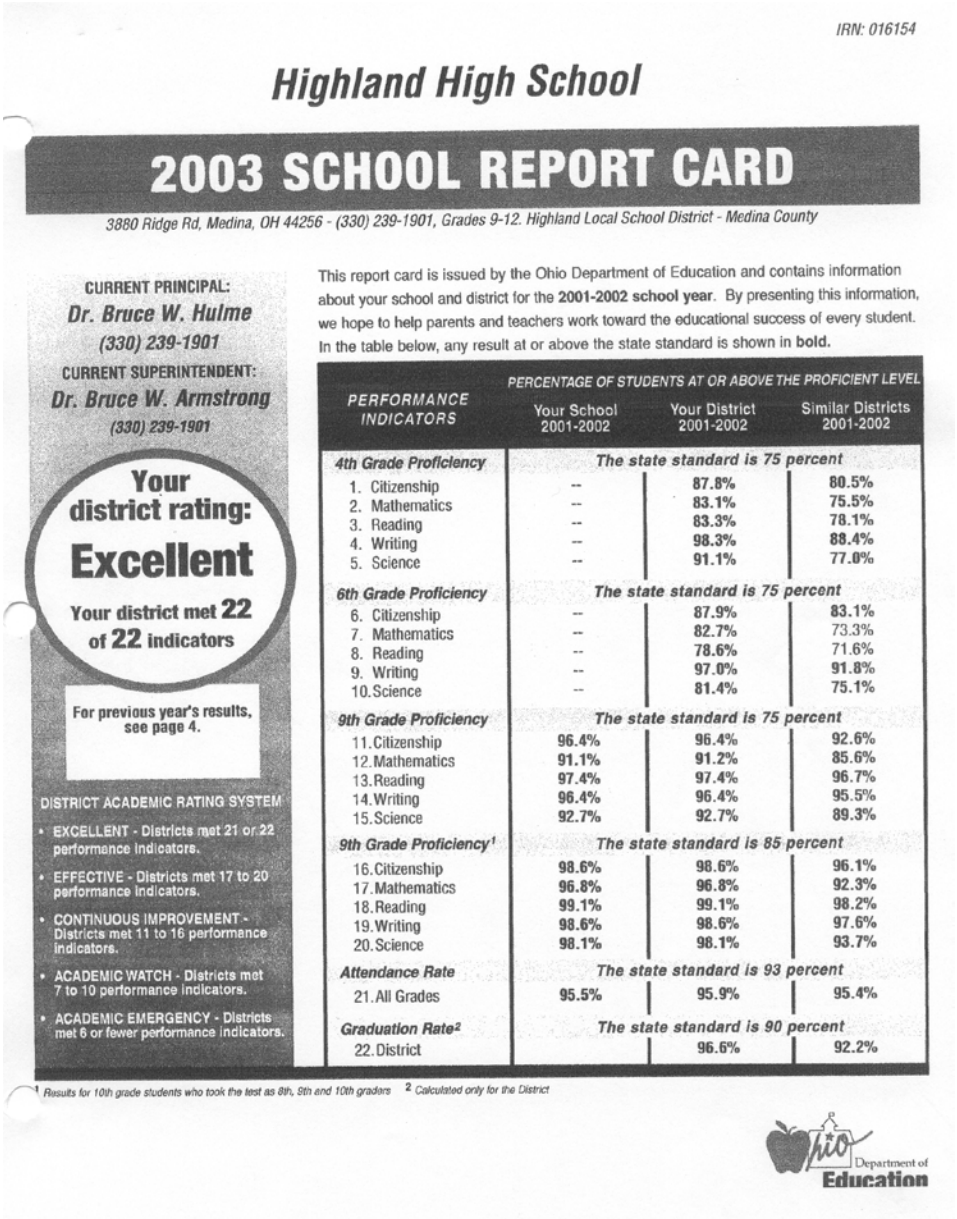
Description of the study

The proposed study is a qualitative study that uses content analysis as the primary method of data collection. A pilot study will be conducted with a group of 15-20 students. The pilot study will be shorter in duration than the proposed study. It will include one data collection session followed by a discussion with the participants in order to gain participant input. The proposed study will present an analysis of the discussions of 30-40 secondary mathematics students who are working in cooperative learning groups. The groups will be audiotaped and a content analysis will be performed on the conversations. While in groups prior to the data collection, the groups will be taped frequently so the taping will eventually be considered an unobtrusive measuring device. The data will be collected three times over a nine-week period. The data will be taken when the students are first forming a cooperative learning group. The second data collection will be during an actual cooperative learning assignment. The third collection of data will be during a review period after the lesson using cooperative learning. The focus of the analysis is listening, positive talk, and role-playing. Since evidence of these skills may be in body language also, data collection will also be performed by direct observation. Non-identifying student journals and a research journal will furnish observation data. Classroom observers will record physical responses of the students on an observation checklist. The use of uninvolved observers will help remove researcher bias.

All participation will be voluntary, as evidenced by permission letters, and participants will be invited to review the results of the final study. Confidentiality will be observed by using only initials when reporting findings and by careful handling of audiotapes during research. The tapes will be located in a locked space at my home. After research is completed, all audiotapes will be re-coded within two years of completion of the study and then destroyed within five years of completion of the study.

APPENDIX C

HIGHLAND HIGH SCHOOL 2003 REPORT CARD



IRN: 016154

Highland High School

2003 SCHOOL REPORT CARD

3880 Ridge Rd, Medina, OH 44256 - (330) 239-1901, Grades 9-12. Highland Local School District - Medina County

CURRENT PRINCIPAL:
Dr. Bruce W. Hulme
(330) 239-1901

CURRENT SUPERINTENDENT:
Dr. Bruce W. Armstrong
(330) 239-1901

Your district rating:
Excellent
Your district met 22 of 22 indicators

For previous year's results, see page 4.

DISTRICT ACADEMIC RATING SYSTEM

- **EXCELLENT** - Districts met 21 or 22 performance indicators.
- **EFFECTIVE** - Districts met 17 to 20 performance indicators.
- **CONTINUOUS IMPROVEMENT** - Districts met 11 to 16 performance indicators.
- **ACADEMIC WATCH** - Districts met 7 to 10 performance indicators.
- **ACADEMIC EMERGENCY** - Districts met 6 or fewer performance indicators.

This report card is issued by the Ohio Department of Education and contains information about your school and district for the **2001-2002 school year**. By presenting this information, we hope to help parents and teachers work toward the educational success of every student. In the table below, any result at or above the state standard is shown in **bold**.

PERFORMANCE INDICATORS	*PERCENTAGE OF STUDENTS AT OR ABOVE THE PROFICIENT LEVEL* Your School 2001-2002	Your District 2001-2002	Similar Districts 2001-2002
4th Grade Proficiency	***The state standard is 75 percent***		
1. Citizenship	--	**87.8%**	**80.5%**
2. Mathematics	--	**83.1%**	**75.5%**
3. Reading	--	**83.3%**	**78.1%**
4. Writing	--	**98.3%**	**88.4%**
5. Science	--	**91.1%**	**77.0%**
6th Grade Proficiency	***The state standard is 75 percent***		
6. Citizenship	--	**87.9%**	**83.1%**
7. Mathematics	--	**82.7%**	73.3%
8. Reading	--	**78.6%**	71.6%
9. Writing	--	**97.0%**	**91.8%**
10. Science	--	**81.4%**	**75.1%**
9th Grade Proficiency	***The state standard is 75 percent***		
11. Citizenship	**96.4%**	**96.4%**	**92.6%**
12. Mathematics	**91.1%**	**91.2%**	**85.6%**
13. Reading	**97.4%**	**97.4%**	**96.7%**
14. Writing	**96.4%**	**96.4%**	**95.5%**
15. Science	**92.7%**	**92.7%**	**89.3%**
9th Grade Proficiency[1]	***The state standard is 85 percent***		
16. Citizenship	**98.6%**	**98.6%**	**96.1%**
17. Mathematics	**96.8%**	**96.8%**	**92.3%**
18. Reading	**99.1%**	**99.1%**	**98.2%**
19. Writing	**98.6%**	**98.6%**	**97.6%**
20. Science	**98.1%**	**98.1%**	**93.7%**
Attendance Rate	***The state standard is 93 percent***		
21. All Grades	**95.5%**	**95.9%**	**95.4%**
Graduation Rate[2]	***The state standard is 90 percent***		
22. District		**96.6%**	**92.2%**

[1] *Results for 10th grade students who took the test as 8th, 9th and 10th graders* [2] *Calculated only for the District*

Ohio Department of Education

APPENDIX D

STATEMENT OF INFORMED CONSENT

Subject's name _____ Date_____

Project Title: Cooperative learning: Student discussions in a high school mathematics classroom

Description and Explanation of Procedure: The proposed study is a qualitative study that uses content analysis as the primary method of data collection. The study will present an analysis of the discussions of sixteen secondary mathematics students who are working in cooperative learning groups. The groups will be audiotaped and a content analysis will be performed on the conversation. The data will be collected three times over a nine-week period. The focus of the analysis is listening, positive talk, and role-playing. Since evidence of these skills may be in body language also, data collection will also be performed by direct observation. On-identifying student journals and a research journal w ill furnish observation data. Classroom observers will record physical responses of the students on an observation checklist.

CONSENT/ASSENT:

(To be completed by the project director)

I have explained to the student, in class, and to the parents or guardians, in a letter, the above-described project and procedures. I affirm that procedures approved for this project by The University of Akron's Institutional Review Board for the Protection of Human Subjects, including those to maintain confidentiality and records will be followed.

Susan R. Phillips (Tel. 330-494-0551) Date _____

(To be completed by parents or guardians)

I have read the letter describing the project and give my permission for the participation of my son/daughter. I know that the director will answer any questions that I may have. If my questions have not been answered adequately, I may request to speak to the Chairperson of The University of Akron's Institutional Review Board for the Protection of Human Subjects (Research Services at 330-972-7666). I am aware that the project is an instructional procedure in cooperative learning to be implemented in the regularly scheduled Mathematics class and that no compensation is available for any physical injury that might occur during that scheduled time. A copy of the Informed Consent Statement will be provided to me upon request. I understand that voluntary non-participation in this project will be without penalty.

_____ Date _____

(Signature of Parent or Guardian)

I understand that audiotaping of students will be used and give permission for this procedure.

_____ Date _____

(Signature of Parent or Guardian)

I understand that observation checklists will be used and give permission for this procedure.

_____ Date _____

(Signature of Parent or Guardian)

(To be completed by the Student)

I have been fully informed of the above-described project and wish to participate knowing that if I must discontinue my participation, it will be without penalty.

_____ Date _____

(Signature of Student)

APPENDIX E

INFORMATION LETTER TO PARENTS

March 14, 2003

Dear Parents or Guardians,

This is a letter requesting _____'s participation in a project I will be conducting in my own Geometry class. The project concerns teaching and learning strategies designed to help students increase their skills in listening, positive talk, and playing different roles in a team. This project has the approval of Highland Superintendent, Dr. Bruce Armstrong, and High School Principal, Mr. Joe Wise.

The project described below is part of my work toward a doctoral degree in secondary education and mathematics instruction at The University of Akron. I hold a permanent teaching certificate from the State of Ohio to teach Mathematics in grades 7-12. I hold a Bachelor of Science degree in Mathematics and a Masters of Arts degree in Curriculum and Instruction. I have eighteen years of teaching experience in mathematics at Highland High School.

In the project, your son or daughter will work in cooperative learning groups. He/She will participate in group discussions during three cooperative learning activities. Students will keep a journal that records class activities, successes, and opinions regarding the strategies they learn to use. At times audiotaping will record students' activities. I anticipate that the project will take three classes over a nine-week time span. The material covered will be consistent with Highland's Course of Study for Mathematics. Disruption of normal classroom routine will be minimal, and I will be evaluating students according to usual procedures. The learning strategies that students will learn in Geometry class may prove useful in their other classes as well.

Please know that confidentiality of all students will be protected throughout this project and in ensuing publication. Students will be identified only by initials. I will keep all audiotapes under lock. The tapes will be used solely for my research purposes and will not be copied or viewed by anyone except a University of Akron recommended transcriber and me. All tapes will be recoded after the research is complete and then destroyed.

Participation of all students will contribute to the validity of the project; however, should a student choose not to participate in the project, there is no penalty. To indicate your consent, please sign, and have your son/daughter sign the enclosed Statement of Informed Consent and return it to me.

There are no anticipated benefits of participation in this research project. If you have any questions, you are welcome to telephone me at school (330) 239-1901. You may also speak to my faculty advisor, Dr. Lynne Pachnowski at (330) 972-7115. This project has the approval of the Institutional Review Board for the Protection of Human Subjects at The University of Akron. Questions may be directed to Research Services, The University of Akron, Akron, OH 44325-2102, or by telephone at (330) 972-7666.

Your interest and cooperation are much appreciated.

Sincerely,

Susan R. Phillips

APPENDIX F

LETTERS OF PERMISSION

Institutional Review Board for the Protection of Human Subjects
The University of Akron
Akron OH 44325-2102
(330) 972-7774

February 10, 2003

To Whom It May Concern:

Mrs. Susan Phillips has received my permission to conduct a research project with Highland High School Geometry and Algebra II students as part of her work toward a doctoral degree in secondary mathematics education at The University of Akron in the Department of Curricular and Instructional Studies. She plans to do the project during the fourth quarter of the 2002-2003 school year.

Sincerely,

Dr. Bruce Armstrong
Superintendent
Highland Local Schools

APPENDIX G

PRIMARY OBSERVATION SHEET

Preliminary observation sheet for first pilot study

		Student	Student	Student	Student
Listening	+				
	-				
Positive talk	+				
	-				
Role playing	+				
	-				

APPENDIX H

SECOND OBSERVATION SHEET

Observer:

Date:

STUDENT (name and dress)				
LISTENING +				
Nodding/shaking head				
Looking at speaker				
Looking at example/calc				
Leaning in				
Puzzled look				
LISTENING -				
Leafing through notebook				
Looking at something else				
Staring off				
More than 1 talking				
Out of desk				
ROLE PLAYING +				
Responds when asked				
Looks at others' work				
Shows work to others				
Group involvement				
Taking turns				
Different people talking				
ROLE PLAYING -				
Controlling				
Disengaged				
Does own thing				

Notes/Comments (on observation checklist):

Notes/Comments (on observed behaviors):

APPENDIX I

OBSERVER THANK YOU

Dear _____,

Thank you for agreeing to help collect data in my classroom (room 21) _____ period on _____.

The form will be complete with the students' initials and color of clothing.

The following guidelines should answer any last-minute questions:

1. Observe, do not listen
2. observe each students' behavior every 2 minutes
3. record (with a check) any behavior that demonstrate + and – listening and role-playing.

I appreciate your valuable time.

Sue Phillips

APPENDIX J

FINAL OBSERVATION SHEET

	Student	**Student**	**Student**	**Student**
POSITIVE TALK +				
Pat on the back				
Thumbs up				
High 5				
OK sign				
Slap hands				
Smile				
Wink				
Hug				
Clap hands				
POSITIVE TALK -				
Not talking				
Roll eyes				
Frown				
Arms folded				
Look of disgust				
ROLE PLAYING +				
Responds when asked				
Open hand out				
Looks at others' work				
Pointing to work				
Sharing work				
Showing work to others				
Time out signal				
Group involvement				
1 person speaking				
Comparing answers				
Taking turns				
Different people talking				
ROLE PLAYING -				
Controlling				
Disengaged				
Leaning back in chair				
Does own thing				
More than one talking				

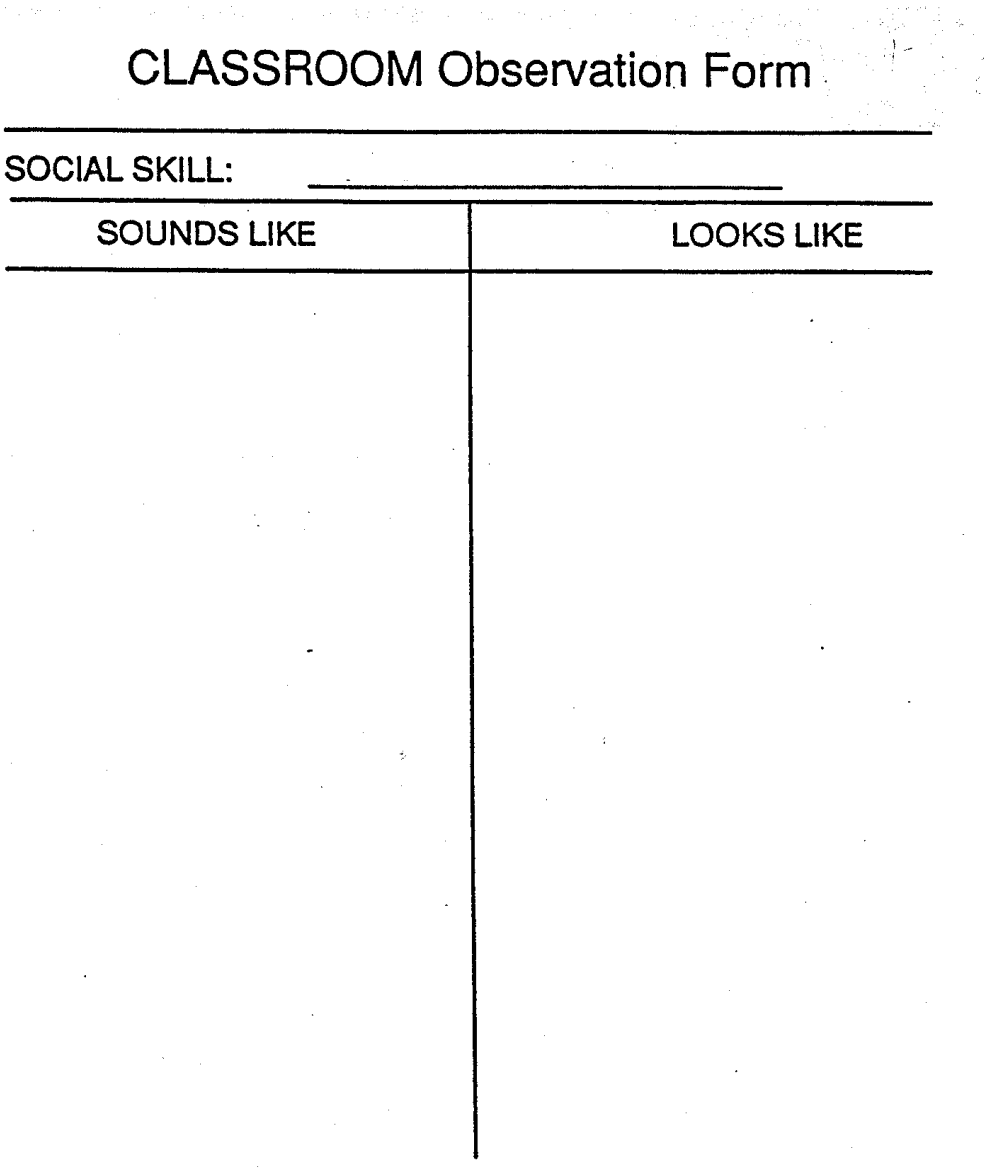
Notes/Comments:

	Student	Student	Student	Student
LISTENING +				
Nodding				
Eye contact				
Concentration on speaker				
Looking at example*				
Taking notes				
Looking at calc*				
Quiet				
Shaking head				
Leaning in				
Sitting close together				
Pointing to material				
Puzzled look				
Squinting eyes				
LISTENING -				
Leafing through notebook				
No eye contact				
Arm folded				
Looking at something else				
Staring				
Nodding off				
More than 1 talking				
Yawning				
Out of desk				
Sleeping				
Drumming pencil				

Notes/Comments:

APPENDIX K

T CHART



APPENDIX L

MATH ATTITUDE QUESTIONNAIRE

MATH ATTITUDE QUESTIONNAIRE

Circle your response for each statement.

Statement	**Agree**	**Disagree**	**Unsure**
1. I like working independently.	A	D	U
2. I like working with a partner.	A	D	U
3. I like working in groups.	A	D	U
4. I prefer working independently.	A	D	U
5. I prefer working with someone else.	A	D	U
6. I like Geometry.	A	D	U
7. I like school.	A	D	U
8. I am concerned about my Geometry grade.	A	D	U
9. I will admit when I need help.	A	D	U
10. I enjoy helping others.	A	D	U
11. I will let others help me.	A	D	U
12. I think I will enjoy cooperative learning.	A	D	U
13. Being accepted by my peers is important to me.	A	D	U
14. I consider myself a cooperative person.	A	D	U
15. Other people consider me a cooperative person.	A	D	U

APPENDIX M

WORKING

WORKING

Almost always like me
Quite a bit like me
Moderately like me
Occasionally like me
Almost never like me

1.	I usually do something I enjoy rather than try something different.	a b c d
2.	I do extra work to make sure things are done just right.	a b c d
3.	I keep and use a list of things I've got to do.	a b c d
4.	I don't usually like others giving me suggestions on how I should do something.	a b c d
5.	When learning something, I first think carefully about the very best way to tackle it.	a b c d
6.	I don't usually ask questions that go much beyond the immediate task at hand.	a b c d
7.	I follow through on things no matter what it takes.	a b c d
8.	When solving a problem, I keep double-checking to be sure I'm right on track.	a b c d
9.	I have found that group decisions are often better than individual decisions.	a b c d
10.	I worry a lot about what could happen when things are changing.	a b c d
11.	I tackle a problem by first trying to see how it affects others.	a b c d
12.	I understand new things by seeing how they fit with what I already know.	a b c d
13.	I check to make sure that others have done what they said they would do.	a b c d
14.	I seek out new activities and responsibilities.	a b c d
15.	I get a job done, even when it's much harder than I first thought.	a b c d
16.	I usually don't make a special effort to learn new things.	a b c d
17.	I make a detailed plan before I tackle a complex problem.	a b c d
18.	I make a mental picture of what I'm trying to learn or solve.	a b c d
19.	I frequently come up with new ideas for how to do things better.	a b c d
20.	I'm usually most comfortable when things are predictable.	a b c d e
21.	I don't usually think about what I need to do until it's almost time to do it.	a b c d e
22.	I explain to others why we need to work together.	a b c d e
23.	I like to experiment with ideas and possibilities in my head.	a b c d e
24.	I don't let go of something until I understand it.	a b c d e
25.	When trying to understand something complicated, I carefully break it into parts.	a b c d e

WORKING

Almost always like me
Quite a bit like me
Moderately like me
Occasionally like me
Almost never like me

26.	I want to see how one task is related to other tasks.	a	b	c	d	e
27.	I won't settle for just doing the minimum on anything, no matter what it is.	a	b	c	d	e
28.	I will offer a suggested solution whenever I bring up a problem to someone.	a	b	c	d	e
29.	I am uncomfortable when I have to handle several things at once.	a	b	c	d	e
30.	It really bugs me to see a problem that nobody is trying to solve.	a	b	c	d	e
31.	I set definite goals, then keep working at them until I've achieved them.	a	b	c	d	e
32.	I like working in teams.	a	b	c	d	e
33.	When I have to wait, I will read anything I find lying around.	a	b	c	d	e
34.	I consciously ask myself questions to see how well I understand something.	a	b	c	d	e
35.	I can't quit thinking about something until I'm sure I've done it very well.	a	b	c	d	e
36.	It can take me a long time to get used to a major change in my life.	a	b	c	d	e
37.	As soon as I finish one task, I look for another one to do.	a	b	c	d	e
38.	If I can't catch on to something quickly, I sometimes just drop it.	a	b	c	d	e
39.	I prefer to learn with other people.	a	b	c	d	e
40.	I prefer to know what's in it for me before I spend a lot of effort learning something.	a	b	c	d	e
41.	I consciously consider several different approaches before tackling a problem.	a	b	c	d	e
42.	I know how to get things done in a system or an organization.	a	b	c	d	e
43.	I usually do my work with great care only if someone will be checking up on me.	a	b	c	d	e
44.	I prefer to let others take the lead in getting something done.	a	b	c	d	e
45.	I learn by figuring out how I can apply the things I'm learning to my life.	a	b	c	d	e
46.	I won't let go of a problem until I've got it licked.	a	b	c	d	e
47.	I adapt quickly to new situations.	a	b	c	d	e
48.	I'm one of the first to volunteer to learn a new procedure or method.	a	b	c	d	e
49.	I'll frequently hold on to my opinion rather than compromise with the group.	a	b	c	d	e
50.	I don't worry about the little details as long as I've done the main things okay.	a	b	c	d	e

You have now completed WORKING. Separate the remaining pages.
Turn to page 7 to begin the scoring process.

APPENDIX N

INDIVIDUAL PROCESSING FORM

Individual Processing

Group name: _____ Your name: _____

Be sure to respond to the following statements on your own. Be as honest as you possibly can using the following scale:

1 = Excellent
2 = Good
3 = OK
4 = Poor
5 = Unacceptable

1. My performance in my role of _____ (indicate your specific role) was

   1 2 3 4 5

2. My performance in contributing equally to the group's goal was

   1 2 3 4 5

3. My use of quiet voice was

   1 2 3 4 5

4. My overall level of cooperation was

   1 2 3 4 5

5. My group members would perceive my contribution as

   1 2 3 4 5

6. I would rate my group members' participation as

   1 2 3 4 5

7. Of the behaviors listed above, I felt particularly good about _____.

8. Next time, I will try to improve _____.

APPENDIX O

GROUP PROCESSING FORM

Group name: _____

Be sure to read and respond as a group. Use the following scale to rate your group's overall performance:

1 = Always
2 = Usually
3 = Sometimes
4 = Rarely
5 = Never

1. We stayed within our own group.

   1 2 3 4 5

2. We used quiet voices.

   1 2 3 4 5

3. All members of the group participated.

   1 2 3 4 5

4. We practiced taking turns.

   1 2 3 4 5

5. We stayed on task.

   1 2 3 4 5

6. We finished our task on time.

   1 2 3 4 5

7. We worked on our previous skill (if applicable).

   1 2 3 4 5

8. In general, we functioned well together in accomplishing our goal.

   1 2 3 4 5

9. Of the behaviors listed above, our group was best at _____.

10. Next time we will be better at _____.

APPENDIX P

LESSON PLAN WORKSHEET

COOPERATIVE LEARNING LESSON PLAN WORKSHEET

Date: _____ Grade Level: _____ Subject:_____

1. Select a Lesson:
   _____
   _____

2. Make Decisions
   a. group size: _____
   b. assignment to groups: _____
   c. room arrangement: _____
   d. materials needed: _____
   e. assigning roles:
      1. _____
      2. _____
      3. _____
      4. _____

3. Set the Lesson
   a. task: _____
      _____
   b. positive interdependence: _____
   c. individual accountability: _____

4. Monitor and Process
   a. observation form: _____
   b. observer(s):_____
   c. plans for processing (feedback): _____

5. Evaluate Outcomes
   a. task achievement: _____
   b. group functioning: _____
   c. suggestions for next time: _____
      _____
      _____

APPENDIX Q

MATH ATTITUDE (POST) QUESTIONNAIRE

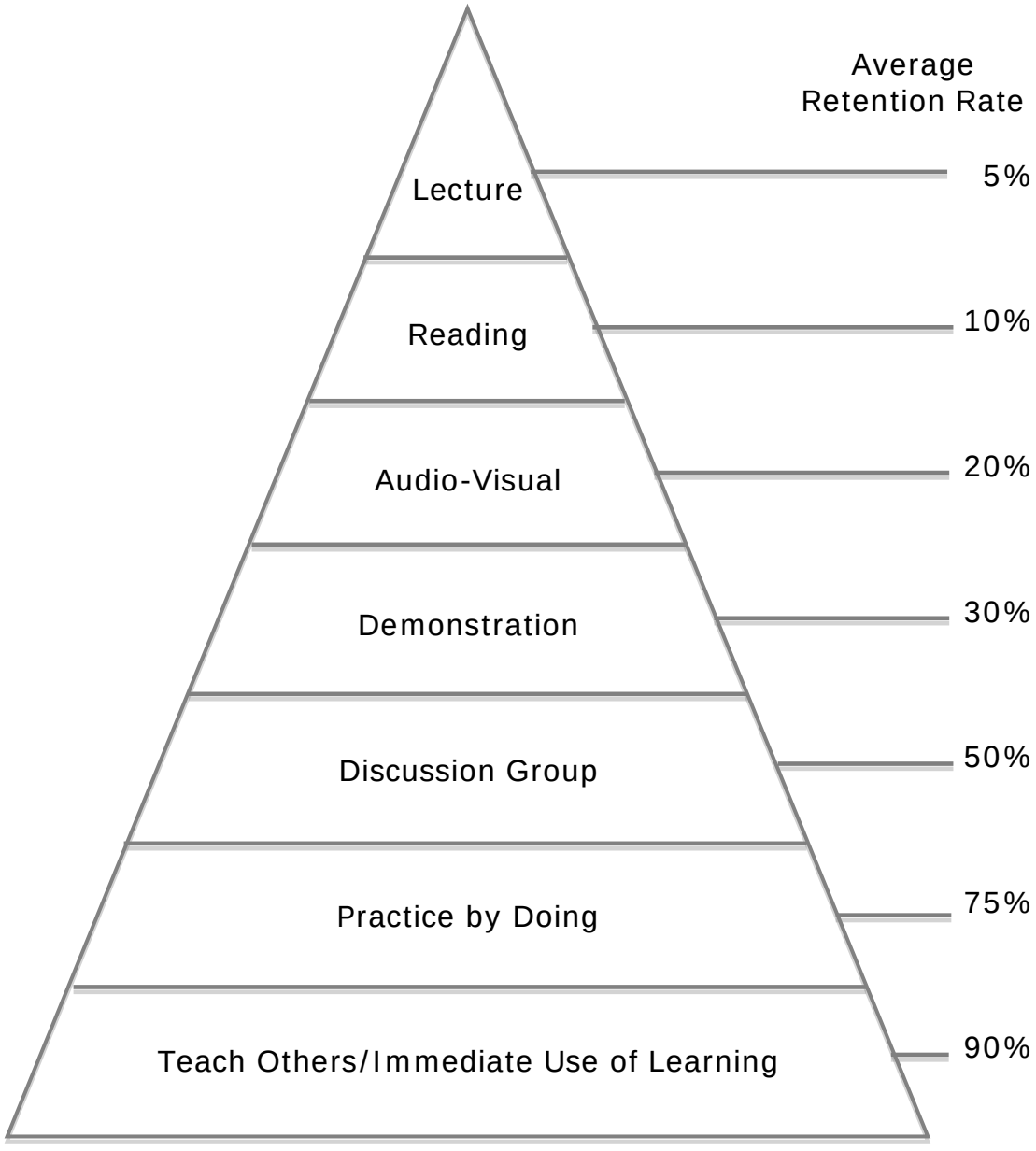
MATH ATTITUDE (POST) QUESTIONNAIRE

Circle your response for each statement.

Statement	Agree	Disagree	Unsure
1. I liked working in groups.	A	D	U
2. I still prefer to work independently.	A	D	U
3. I like Geometry better when working in groups.	A	D	U
4. I admitted when I needed help.	A	D	U
5. I enjoyed helping others.	A	D	U
6. I will let others help me.	A	D	U
7. I enjoyed cooperative learning.	A	D	U
8. I consider myself a cooperative person.	A	D	U
9. Others consider me a cooperative person.	A	D	U

APPENDIX R

LEARNING PYRAMID



APPENDIX S

FIVE BASIC ELEMENTS OF COOPERATIVE LEARNING

1. Positive Interdependence: materials, goals, grades
2. Face to Face Interaction: roles, responsibilities, appreciating differences
3. Individual Accountability: projects, tests, assignments
4. Interpersonal and Small Group Skills: listening, questioning, encouraging, reaching consensus
5. Group Processing: Reflection, analysis, feedback

(C. Helstrom Professional Growth Programs 1/21/98)

APPENDIX T

G-R-O-U-P-S

Give encouragement and support

Respect others by listening to their ideas

On task and get the job done

Use quiet voices

Participate actively and give own ideas

Stay with group until the job is done

APPENDIX U

RECTANGLES