

Improving High School Mathematics  
Instruction: Using Constructivist Pedagogy

by  
Kimberly L. Neal

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Approval Page

This applied dissertation was submitted by Kimberly L. Neal under the direction of the persons listed below. It was submitted to the Fischler School of Education and Human Services and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova Southeastern University.

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E. Robert Erbe, EdD  
Committee Chair

---

Date

---

Marcelo Castro, PhD  
Committee Member

---

Date

---

Maryellen Maher, PhD  
Dean of Technology and Research

---

Date

## Abstract

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This applied dissertation was designed to enable 11th and 12th grade students to perform at the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam. Students who were repeating the test did not meet standards on the mathematics subtest after multiple attempts, did not meet the predetermined passing score on an in-class achievement test in mathematics, and obtained classroom grades, in mathematics, below the 75% mark. In addition, based on teacher observation, high school students did not demonstrate sufficient motivation to master grade-level basic skills concepts in mathematics.

The writer developed a program using constructivist pedagogy to address the issues associated with below proficiency scores in basic skills in mathematics on the state exit exam. Topics focused on collaborative learning, cooperative learning, and computer-assisted instruction for a 16-week period. Students used peer-assisted instruction each Tuesday of the program, cooperative groups once a month, and computer-assisted instruction each Thursday of the program. Furthermore, a self-made questionnaire was administered at the end of the program to determine if students prefer the peer-assisted learning approach and to determine their attitude towards learning mathematics using constructivist-learning methods.

An analysis of the data revealed that students enjoyed using constructivist methods to learn and posttest scores improved over pretest scores. However, classroom grades were not significantly changed and classroom attitudes about math were not affected.

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## Chapter 1: Introduction

### *Description of Community*

The school for which this instruction was planned is in a rural area of the southeast United States. According to the 2000 census, the population of the city in which the school is located is estimated at 8,000. The city is 60% white, 38% African American, 1% Hispanic, and 1% other. The median household income is \$26,620, with 23% of the population living below the poverty level. High school graduates make up 60% of the population, and 18% of the population have bachelor's degrees or higher. The unemployment rate, as of September 2003, was approximately 9%. The average national unemployment rate for 2003 was 6% (U.S. Department of Labor, n.d.).

### *Writer's Work Setting*

The school is a Flagship School of Promise and is fully accredited by the Southern Association of Colleges and Schools. The Mission Statement for the school is "Building Success: Today, Tomorrow, Together. Preparing all learners to be contributing, successful citizens in a complex, changing world."

This is the only high school in the district. The school is on a 4 x 4 block schedule. The school faculty consists of 65 teachers, three guidance counselors, one administrative assistant, two assistant principals, and one principal. The math department of the school for which this instruction was proposed consists of nine faculty members. The population of students consists of 54% white, 45% African American, 1% Hispanic, and less than 1% other.

### *Writer's Role*

The writer has been employed as a full-time mathematics teacher at this school for the past seven years and serves as the department chair for the mathematics

department. The department chair serves as facilitator of all departmental meetings, coordinates schedules with the math teachers, and acts as a go-between between the administration and the department.

## Chapter 2: Study of the Problem

### *Problem Statement*

The problem to be solved in this applied dissertation is that 11th and 12th grade students perform below the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam.

### *Problem Description*

All 10th grade students are required to meet the standard on the state-mandated exit exam in order to graduate with a diploma. If a student does not meet the proficiency level in the 10th grade, they have three more opportunities before graduation. Students who fail to meet state-mandated levels of proficiency on the exit exam in mathematics have consistently scored below average on in-class achievement tests in mathematics thus increasing their low self-esteem in mathematics that in turn enhances their lack of motivation. In addition, integration of calculators in the elementary, middle and secondary classrooms has further weakened students' abilities to meet predetermined passing scores on achievement tests which do not allow the use of a calculator.

### *Problem Documentation*

Evidence that the problem exists can be found in the scores from the state exit exam that indicate 26 of 47 students who are repeating the test did not meet standards on the mathematics subtest after multiple attempts. In addition, when examining the scores from a basic skills, in-class achievement test in mathematics, 29% of the 10th grade students did not meet the predetermined passing score. Furthermore, examination of classroom grades, in mathematics, of students who did not meet standards on the mathematics subtest show marks below 75%.

### *Causative Analysis*

One cause of students performing below the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam is that high school students demonstrate deficits in basic computational skills in mathematics. Integration of, and reliance upon, calculator use contributes to this deficit. Students begin using calculators at the elementary level and many high school students have not learned basic skills concepts in mathematics before they enter the 10th grade.

Secondly, an examination of students' school records indicates a pattern of low achievement in mathematics on standardized tests in elementary and middle school. When students are asked to complete computations without the use of a calculator, they have difficulty. This difficulty leads to a third cause, insufficient motivation to master grade-level basic skills concepts in mathematics thus compounding the problem even further.

### *Relationship of the Problem to the Literature*

Many topic areas were researched, including hands-on math, for this dissertation. Some of the topics include hands-on math, computer math, applied math, technology, constructivist theory, and secondary school students. The most relevant research insights concerned theoretical perspectives, teaching methods, learning strategies, and the impact of better scores on students.

A review of the literature yielded a research area of constructivist pedagogy that included aspects of constructivist teaching strategies and the role those strategies can play in the improvement of student achievement in mathematics. A major tenant of constructivist theory requires that instruction provide for active student learning. Students are to connect past experience and learning with new information and skills. The theory

emphasizes student construction of meaning and de-emphasizes reliance upon passive reception of direct instruction. Instead of lecturing and telling students the expected answer, the teacher acts as a mentor and asks questions to help them discover the answer themselves (Sprague & Dede, 1999). By listening and communicating with their peers, learning activities help to increase academic skills and to promote a deeper level of understanding of the subject matter. When using a behaviorist approach to teaching, students are not really interested, but are trying to go along with the expected and give rote answers that have been memorized. The constructivist teaching approach appeals to a student's interests and development of reasoning. Here, the teacher has a minimal authoritarian role whereas behaviorists believe the ideal situation is one in which adult-child partners are unequal. This approach is an instructional factor in the quality of student learning.

*Importance of constructivist teaching strategies.* According to much of the constructivist literature, it appears highly presumptuous of teachers to assume that their instructional strategy is the best learning strategy for all students. As Piaget (1932) pointed out, each child has thoughts and feelings of their own. A child brings those feelings and thoughts into the classroom where they will form their own opinions about what and how they learn. Piaget described developing knowledge as a relationship between the child's current cognitive system and the particular object, task, or problem at hand. De Lisi (2002) pointed out that peer learning activities can optimize cognitive gains as described in Piaget's research on developmental theory, if an optimal learning relationship where a student feels that his or her learning efforts are respected and valued by teachers and by classmates is in place. De Lisi remarked that, if students feel disrespected by a teacher or classmate or their efforts to learn are not appreciated, they

will approach tasks with little regard for learning. When teachers foster an atmosphere of mutual respect in the classroom, students feel more inclined to involve themselves in the learning process.

Mathematics education is one area that constructivist teaching strategies can be beneficial in helping the student learn. Use of constructivism provides educators an approach to understanding how people learn (Draper, 2002). Using constructivist pedagogy, teachers can adapt the mathematics classroom to the students needs, engaging them in meaningful conversations involving mathematics and allowing them to construct new knowledge in mathematics. Grant (1998) and Noddings (1993) claimed that mathematics educators are calling for teachers to move away from teaching by telling and move toward the constructivist teaching paradigm. The Principles and Standards for School Mathematics that the National Council of Teachers of Mathematics (as cited in Draper) developed calls for a more student-centered math classroom which de-emphasizes rote memorization of isolated skills and facts and emphasizes problem solving and communication. These types of statements are but a few of the calls for reform in the classroom that are echoing in the world of education. In answer to the call, many proponents of mathematics reform have advocated a constructivist perspective of teaching and learning. According to Draper, constructivism is the philosophy, or belief, that learners create their own knowledge based on interactions with their environment including their interactions with other people. Furthermore, Larochelle and Bednarz (1998), claimed constructivist recognize (a) that experience and environment play a large role in how well the learner learns and (b) that language plays a key role in the acquisition of knowledge. In addition, Richardson (1997) explained that constructivism is not a precept for learning, but rather a descriptive theory of learning. Educators may

know how learning should take place, they just may not be sure of exactly what students should learn and they may be unsure of how best to help students construct this knowledge.

There are many classifications for the theories about how children learn (Pa, as cited in Cathcart, Pothier, Vance, & Bezuk, 2000). While each approach will garner results, the types of results are different. According to Cathcart et al. (2000) these theories have a significant bearing on how mathematics is taught. Teachers employ different models depending upon the setting and their beliefs about how children learn. The job then, for teachers, is to know the students and be familiar with the subject so that the best learning environment can be established for each child.

Vygotsky (1978) believed that a child's zone of proximal development (ZPD) is the distance between the actual development level when working independently and the potential development level when using direct teaching methods. Piaget's ideas, on the other hand, promotes a feeling of community in the classroom where each child will hold varying degrees of interest in what is being learned according to their opinions about what and how they learn. In this instance the teacher is a mentor. The difference between these two interventions lie in how the teacher intervenes, in what circumstances, and how often (DeVries, 2002). Both perspectives involve a change in what the student learns. The emphasis seems to be a matter of degree in how much they learn.

According to Johnson, Dupuis, Murial, Hall, and Gollnick (1996) meaningful learning can take place when teachers employ activities that call on students to use their prior knowledge and experiences to construct their own frames of thought. Students learn when they believe they have a stake in such learning. One method that is available is the peer learning approach. Classwide peer tutoring (CWPT) (Smith, 1997) is a powerful

instructional procedure that actively engages all students in a classroom and promotes mastery, accuracy, and fluency in content learning for students.

Peer learning is a powerful tool if and when it is used correctly. The amount of planning required on the teacher's part can be, at first, quite demanding. The teacher must develop the activities, coordinate the activities, and evaluate the effectiveness of the process. Peer learning requires a major shift in focus from what is being taught to what is being learned and requires the student to take more responsibility for their own learning (Cooper, 2002). Allowing the student greater control of their learning also provides an increased level of satisfaction for the student. Studies (Andrews, 1992; Cooper & O'Donnell, 1996) show a student has a greater sense of partnership with instructors in the learning process and an increased cognitive, social, and emotional benefit when there is direct interaction between the teacher and the student. In peer learning, the teacher models expert learning and problem-solving strategies which the student, in turn, observes and reflects upon to apply in their own setting. Heller and Hollabaugh (1992) discussed how this observe-reflect-discussion-apply pattern promotes gains for students of all ability levels, especially in analysis and solution of problems. Cooper (2002) remarked that, key elements in creating a match among goals, outcomes, and implementation strategies are the classroom environment and the place of technology within the environment, the stance of the teacher, and the choice of task and dialogues. By paying careful attention to these aspects of the learning process, peer learning can be a powerful instructional tool.

Another method of peer learning is the Guided Reciprocal Peer Questioning, whereby peer learning can be structured to ensure that learners engage in high-level cognitive processing (King, 2002). According to theories of the social construction of

knowledge (e.g., Bearison, 1982) asking and answering thought-provoking questions that force students to think and clarify concepts, elaborate on them, reorganize thinking, or reconceptualize the material in some manner improves comprehension for the individual doing the explaining. King pointed out that, depending upon which perspective one adopts, a Vygotskian one where learning is socially constructed during interaction and activity with others or a Piagetian one where social construction of knowledge takes place during interaction with peers and the solving of differences in each other's current understanding of the a topic, Guided Reciprocal Peer Questioning techniques promotes high-level thinking and learning. However, the peer learning approach a teacher selects should match the requirements of the learning task since different types of interaction facilitate different kinds of learning. Therefore, if a high cognitive level of interaction is in place within the group, then high-level complex learning will take place, learning that is characterized by the exchange of ideas, information, perspectives, attitudes, and opinions (Cohen, 1994). By using peer learning tasks that demand a higher, more complex, level of cognitive processing, students work together to solve problems, analyze and integrate ideas to go beyond presented material to build new knowledge, make group decisions, use peer assessment of learning and engage in peer tutoring (King, 2002). This type of interaction goes beyond the material presented to the acquisition of, and use of, new knowledge.

Use of cooperative groups can help with peer learning. Leikin and Zaslavsky (1999) proposed four necessary conditions for a cooperative-learning setting: Students learn in small groups; the learning tasks in which students are engaged require that the students mutually and positively depend on one another and on the group's work as a whole; the learning environment offers all members of the group an equal opportunity to

interact with one another regarding the learning tasks and encourages them to communicate their ideas in various ways; and each member of the group has a responsibility to contribute to the group work and is accountable for the learning progress of the group. Forming of groups in the classroom is not and should not be a façade to genuine cooperative learning settings. Careful planning should be used to establish the number of students in a cooperative group and to ensure a degree of heterogeneity. Using cooperative-learning settings promotes task-related interactions by students and promotes students' active explorations in the mathematics classroom.

According to King and Parent-Johnson (1999) Palinscar and Brown developed one of the most successful and widely researched approaches of instruction and guided practice for content literacy: reciprocal teaching (RT). According to Vygotsky (1978) a facilitator's role is to lead a dialogue in order to scaffold learning. In RT, the teacher and the students each take turns assuming the role of facilitator. Using RT strategies enables students to demonstrate collaborative efforts, which enable them to build understanding. Evidence that students are constructing meaning can be seen by their engagement in meaningful dialogue. Not only does RT enable the student to construct meaning, it also enables them, through their group interactions, to become aware of the importance of peer feedback and support (King & Parent-Johnson, 1999). Roschelle (1992) defined collaboration as the construction of shared meaning for conversations, concepts, and experiences. Palinscar and Herrenkohl (2002) extended this definition by attaching conditions for promoting collaboration. When working on a task, all members of the group share cognitive responsibility for the task at hand. According to Palinscar and Herrenkohl reciprocal teaching (RT) was designed as an educational intervention for students who demonstrate significant disparities between their ability to decode and

comprehend text. Mercer (1992) defined peer tutoring as a dyad, or the pairing of two students, to enhance and extend academic instruction. Pairing an average to above-average student with a lower achieving student allows for demonstration and modeling by the tutors. This provides a structured learning environment that encourages active student participation (Smith, 1997). According to Johnson and Johnson (1985) and Slavin (1989) collaborative learning requires a dynamic participation of individuals working together to construct knowledge. Keller (1983) defined satisfaction as the perception of being able to achieve success and feelings about the achieved outcomes. Regardless of which collaborative method is used in the classroom, each share commonalities. Palinscar and Herrenkohl remarked that, students are learning to respect each others' ideas and begin to realize the importance of the contributions of each student, thereby making the classroom environment one where both debate and consensus are welcomed. After-all, as Palinscar and Herrenkohl pointed out, by creating a shared social world, one is learning to engage in collaborative learning.

Teachers recognize that learning is not a solitary activity. Decades of research tell us that students learn the most when they work cooperatively (Johnson, Johnson, & Maruyama; Slavin, as cited in Putnam, 1997). Not only do people learn through various modalities, such as the auditory, kinesthetic, or visual channels, they also learn in a variety of interpersonal or intrapersonal contexts (Putnam, 1997). The basic five methods of cooperative learning used in education are each unique in their own way. Putnam pointed out that there is no one method or model of cooperative learning that is perfect for all situations. Each model has characteristics that are unique to that particular model. The model that is selected for use should depend upon instructional goals and purposes of the instructor and the make-up of the classroom.

Structuring cooperative learning well takes time. But it is time well worth the effort. Students in a cooperative learning group can engage in different levels of tasks and learn different amounts of material. Every student learns something that he or she does not already know and all students contribute to a common goal (Schniedewind & Davidson, 2000). The support and feedback from the cooperative group member's helps each student to check their individual progress while learning how to work together as a team. When implementing cooperative learning, there are a few points that should be considered. Cooperative learning activities should be designed for multiple intelligences. This will provide activities where each student can excel in the area where they are the strongest. The criteria for success should be varied so that all members of the group are appropriately challenged without compromising the end results or finished project. Every cooperative group member will benefit from the social interaction that takes place. Social skills that are learned from working in a cooperative group will extend far beyond the scope of the classroom. It is important to remember that individual accountability is combined with teamwork in cooperative learning. But by differentiating learning within cooperative groups students are given opportunities to work with their peers in meaningful and challenging ways (Andrews, 1992; Cooper & O'Donnell, 1996; Jonassen, 1996; Putnam, 1997; Springer, Stanne, & Donovan, 1999).

Cooperative learning opportunities provide students an alternative method of learning which may suit their individual needs better than the lecture mode of teaching. A more effective method may be one in which peers explain using language that can translate difficult vocabulary into language that fellow students can understand (Noddings, 1993). When students are involved in a peer learning situation, the emphasis is on collaboration within the group. This collaboration provides opportunities for

students and teachers to accomplish behavior that is productive to learning. To benefit from cooperative learning, the learner must be an active participant in the learning process (Webb, Farivar, & Mastergeorge, 2002).

As technology becomes more prominent in the classroom of the 21st century, teachers and students must learn to utilize the technological tools available. Using computer-based instruction (CBI) and classwide peer tutoring (CWPT) together is one way to successfully integrate an instructional alternative to achieve specific individual and classroom goals. Cavalier and Klein's 1998 study suggested that cooperative learning may be as effective as individual learning when students use well-designed CBI but it may not always increase student achievement or improve attitude. Use of computer-supported collaborative learning has the potential for providing collaborative learning and learner satisfaction. Wang, Hinn, and Kanfer's (2001) study failed to detect any significant interaction between learning styles and the computer-supported collaborative learning (CSCL) program entitled Toward an Integrated Learning Environment (TILE), but the results suggested that CSCL environments support diverse learning styles and provide student learner satisfaction. But successful integration of CBI and CWPT necessitates teacher training, planning, and role flexibility, and the use of an instructional arrangement to facilitate integration (Smith, 1997). According to Greenwood, Delquadri, and Carta (1988) there is an impressive research base that supports Light and Mevarech's (1992) statement that integrating CBI and CWPT not only facilitates academic responding and learning, it fosters self-esteem, social development, and problem-solving skills. Therefore, schools will need to provide or teachers will need to seek instruction on how to select software that focuses on appropriate matches between the lessons' instructional objectives and implementation of CWPT.

The constructivist theory posits that students make sense of the world by synthesizing new experiences into what they have previously understood. Constructivist teachers organize information around conceptual clusters of problems and questions as opposed to facts in isolation (Sprague & Dede, 1999). Using constructivist theories, teachers encourage student inquiry and allow student responses to drive the lesson plans, modifying as they go, if needed. Students are actively involved in their learning. They are sharing ideas, asking questions, and discussing concepts. Such activities are often more motivating and interesting to students and result in creating knowledge that is lasting (Andrews, 1992; Cooper & O'Donnell, 1996; Jonassen, 1996; Putnam, 1997; Springer, Stanne, & Donovan, 1999).

*Learning strategies and teaching methods.* How can teachers ensure that learning is interesting and meaningful for students? Teachers that are concerned about relegating the power to the student feel as if they will lose control or not fulfil their role or worse, be seen as less effective by parents, principals, or supervisors (Sprague & Dede, 1999). Adopting change, in any area, can be difficult. The uncompromising teacher needs mutual respect and understanding while adopting new practices. As Morin (2001) stated, the question is "Can we be as patient with our teachers as we are with our students?" (p. 65). Implementing any change can be difficult, a challenge even, but change can be for the better.

As Richetti and Sheerin (1999) pointed out educators who are not willing to recognize the student as an important part of the classroom learning environment might ask why would we need to understand the students point of view if the teacher's view is the only one that matters. Constructivism depends upon listening to the student. Richetti and Sheerin remarked that, obtaining the ability to ask and consider important questions

enables the student to be a lifelong seeker and integrator of new knowledge. In essence, being an effective questioner is essential to being an effective thinker and learner. Hyerle (1996) pointed out that the central problem that Constructivist educator's face is not a lack of guiding theory, but concrete strategies and tools for institutionalizing these theoretical and practical understandings into more inclusive classrooms. Use of Socratic questioning techniques, or question-based problem solving strategies, is one type of tool that provides a systematic approach that helps students ask important questions. Ernest Boyer, president of the Carnegie Foundation for the Advancement of Teaching, advanced this belief with his statement that an educated person today is someone who knows the right question to ask (Fiske, 1991). By learning question-based problem solving strategies, students can become more effective thinkers and learners.

Regardless of which strategy is used, student's attitudes and beliefs about learning must be considered. Students acquire an optimism or pessimistic outlook on life during their primary school years and this influences students' task involvement which is related to their achievement (Yates, 1999). Learning and performance goals influence students' attitudes towards and engagement in school work (Woolfolk, 1998). It is often believed that mathematics is considered to be a subject only for the very able (McLeod, 1992). Yates claimed that behaviors within the mathematics classroom are a direct result of these attitudes and beliefs that influence students' expectations towards mathematics, particularly in relation to failure. Furthermore, literature (Bandura, 1977; Hembree, 1990; Reyes, 1984) suggests that students' levels of anxiety, self-confidence, self-concept, and self-esteem have a direct relationship on achievement in mathematics. Teachers play an important role in the development of students attitudes and motivation and must be cognizant of these contributions.

According to Dunn, Beaudry, and Klavas (1989) learning style is a biologically and developmentally derived set of variables that affect the way one learns and interacts with the surrounding environment. Cohen (2001) contended that a student's learning style can be affected through external factors in the learning environment. By using multiple representations, including real-world situations, manipulative materials, pictures, spoken symbols, and written symbols, students develop a stronger understanding of mathematics concepts. It also enables teachers to reach students with different learning styles (Bezuk, as cited in Cathcart, Pothier, Vance, & Bezuk, 2000). The use of technology in constructivist teaching practices can also have a positive impact on student learning.

However, results of the ANOVA procedure and t-test in a 2001 study completed by Wang, Hinn, and Kanfer did not reveal any significant relationships between students' learning outcomes and their learning style when using a computer-supported, collaborative-learning setting. Wang, Hinn, and Kanfer (2001) concluded that this could be a result of within-group variance that concealed real differences and/or the author's inability to control previous learning and motivation. In addition, satisfaction levels may be affected by the novelty of using the program for some learning style groups.

Many educators are willing to recognize the student as an important part of the classroom learning environment. Cohen's study (2001) suggested that the school environment can change a student's learning style. One high school, the Academy for the Advancement of Science and Technology (AAST), used a project-based approach to learning with a technology-rich environment. Students at AAST are considered above average academically. Nonetheless, an administration of Dunn and Dunn's Learning Style Inventory (Dunn, Dunn, & Price, 1989) showed four of the six variables studied showed a significant change for AAST students. Interview questions provided insight

into the students perception of technology use and its relevance to their lives.

One use of technology is the Internet. Use of the Internet can be a promising technique or strategy for constructivists teaching practices. It can provide peer interaction and can increase students' opportunities to access information that might otherwise be unavailable to them. In addition, students can report new information to teachers, thus teaching the teacher. These practices offer opportunities for higher-order thinking and enable the student to fortify his or her knowledge (Green & O'Brien, 2002).

Schacter (1999) summarized several studies (Baker, Gearhart, & Herman, 1994; Harel, 1988, 1991; Kulik, 1994; Mann, 1999; Scardamalia & Bereiter, 1996; Sivin-Kachala, 1998; Wenglinsky, 1998) which analyzed the impact of educational technology on student achievement and student attitude towards learning. According to these studies, students who use educational technology improve their scores on tests therefore improving their outlook, and thusly, their attitude towards learning mathematics. Dr. Martha Stone Wiske, co-director of the Educational Technology Center at the Harvard Graduate School of Education, (as cited in Schacter, 1999) proclaimed that a difficulty about technology and education is that technology is often thought of first and education later. Several factors must be considered if effective implementation of educational technology is to take place. The availability of the technology, the specific program being used and how it is tied to the learning objectives, the teacher's training, the amount of time spent using the program (both student and teacher), and prior skills of the students must be addressed before the program is put into place.

*Theoretical perspectives: Piaget and Vygotsky.* When examining the theories of Vygotsky (1978) and Piaget (1932), sometimes it may be difficult to separate the two. According to DeVries (2000) there is a presence in Vygotsky's writing of both

behaviorist and constructivist conceptions. DeVries asserted that it is not surprising that some educators draw from Vygotsky's work educational implications that are behavioristic, and others draw implications that are constructivist. Both Vygotsky and Piaget spoke in great depth on the social factors that play a central role in a child's development. Sinclair (1996) pointed out that Vygotsky emphasizes the content of development while Piaget emphasizes the structure of development. The concept of social development, for Piaget, was one where the student went from a lack of awareness of one self, to an understanding of others perspectives and subsequently situated oneself somewhere in that system. According to Sinclair, what Vygotsky meant by social was society. In education, the teacher must be a part of that social system. DeVries remarked that, the difference between these two interventions lie in how the teacher intervenes, in what circumstances, and how often. Regardless of which doctrine one holds to DeVries (2000) pointed out that there is a convergence between some Piagetian and Vygotskian educational beliefs. Both believe children are viewed as active; rote learning should be avoided; the whole language approach to literacy is advocated; collaboration of children in classroom activities is advocated; establishing community in the classroom is important; curriculum should be based on children's interests; external rewards should not be used with children; and pretend play is an important part of the curriculum. Furthermore, DeVries stated that, to reconcile the two theories Vygotskians will need to reevaluate the idea that teachers are the authority figure and move towards a cooperative classroom atmosphere. Piagetians will need to recognize the role of culture in a students life and how it affects learning in the classroom.

Students who are actively engaged in their learning have an opportunity to express their thoughts, opinions, and ideas in such a way that the material is made more

interesting to them. This provides a more meaningful learning experience than a classroom using a lecture mode of instruction. According to Bevevino, Dengel and Adams (1999) the use of constructivist theories in the classroom allows the students to clarify their thought processes and correct their misconceptions because they have the opportunity to explain, to argue, and to debate their ideas. By listening and communicating with their peers, learning activities help to increase academic skills and to promote a deeper level of understanding of the subject matter. As Piaget's (1932) research pointed out, each child has thoughts and feelings of their own. A child brings those feelings and thoughts into the classroom where they will form their own opinions about what and how they learn. Piaget described developing knowledge as a relationship between the child's current cognitive system and the particular object, task, or problem at hand. De Lisi (2002) pointed out that peer learning activities can optimize cognitive gains as described in Piaget's research on developmental theory, if an optimal learning relationship where a student feels that his or her learning efforts are respected and valued by teachers and by classmates is in place. If students feel disrespected by a teacher or classmate or their efforts to learn are not appreciated, they will approach tasks with little regard for learning. When teachers foster an atmosphere of mutual respect in the classroom, students feel more inclined to involve themselves in the learning process. By listening and communicating with their peers, learning activities help to increase academic skills and to promote a deeper level of understanding of the subject matter.

*Cooperative learning.* Teachers recognize that learning is not a solitary activity. Decades of research tell us that students learn the most when they work cooperatively (Johnson, Johnson, & Maruyama; Slavin, as cited in Putnam, 1997). Putnam (1997) recalled that people learn through various modalities, such as the auditory, kinesthetic, or

visual channels and they also learn in a variety of interpersonal or intrapersonal contexts. The basic five methods of cooperative learning used in education are each unique in their own way. There is not one method or model of cooperative learning that will work every time. Each model has characteristics that are unique to that particular model. David Johnson and Roger Johnson promote the Learning Together model. The Learning Together model incorporates five key features: (a) positive interdependence, (b) individual accountability, (c) face-to-face interaction, (d) direct teaching of cooperative skills, and (e) monitoring and processing of groupwork. Spencer Kagan uses the Structural Approach. The Structural Approach uses a series of steps and prescribed behaviors that are not tied to specific academic content. Robert Slavin developed the Student Team Learning (STL) model. The STL model incorporates Student Teams-Achievement Divisions (STAD), Teams-Games-Tournaments (TGT), Jigsaw II, and Team Assisted Individualization (TAI). In each of the components of STL, students are encouraged to help their teammates succeed and to care about one another's learning. Shlomo Sharan and Yael Sharan developed the Group Investigation model where students are actively engaged in the instructional process by requiring that they carry out investigations, integrate their findings, and make presentations to the class. Elizabeth Cohen's strategy is called Complex Instruction. Putnam explains Complex Instruction is targeted for heterogeneous classrooms of students from grades 2 through 5 where the methods are designed to foster higher-order thinking and conceptual development through challenging, intrinsically motivating, multi dimensional tasks. Each of these five models has common characteristics. The model that is selected for use should depend upon instructional goals and purposes of the instructor and the make-up of the classroom.

When teachers use cooperative learning thoughtfully and differentiate tasks

within it, they can personalize student learning, help students collaborate while challenging each individual in the context of a group effort, and encourage students to appreciate their peers' diverse competencies and experiences (Schniedewind & Davidson, 2000). This is a change from the lecture mode of teaching and learning. When teachers use cooperative groups it allows students to receive personalized instruction and provides the students an opportunity to collaborate with their peers, thus learning how to work as a team but remain individually responsible. In addition, this teamwork enables the student to encounter diverse backgrounds and learn appreciation for each other's differences. When teachers create a positive climate for cooperative learning, higher achievement, higher self-esteem, improved cross-ethnic relations, peer acceptance, improved behavior, and improvement in social skills are a few of the advantages that result from cooperative approaches (Putnam, 1997).

Cooperative learning is not restricted to a classroom setting. According to Cavalier and Klein (1998), previous research has shown positive effects for achievement and attitude when small group strategies were used with computer-based instruction (CBI). Furthermore, when individual and cooperative methods were used with CBI, they were as equally effective. The results from Cavalier and Klein's 1998 study suggested that cooperative learning may be as effective as individual learning when students use well-designed CBI but it may not always increase student achievement or improve attitude. Klein and Pridemore (1994) suggested that the mixed results for studies may be because of the orienting activities employed within mediated lessons. According to Cavalier and Klein working cooperatively increases learning of relevant information. Mean scores for an attitude survey given to the students in Cavalier and Klein's study also suggested that most students liked using the computer program and working in a

cooperative environment. Further studies should be explored to investigate the effect that computer-based instruction has on learning.

Leikin and Zaslavsky (1999) proposed four necessary conditions for a cooperative-learning setting: Students learn in small groups; the learning tasks in which students are engaged require that the students mutually and positively depend on one another and on the group's work as a whole; the learning environment offers all members of the group an equal opportunity to interact with one another regarding the learning tasks and encourages them to communicate their ideas in various ways; and each member of the group has a responsibility to contribute to the group work and is accountable for the learning progress of the group. Forming of groups in the classroom is not and should not be a façade to genuine cooperative learning settings. Careful planning should be used to establish the number of students in a cooperative group and to ensure a degree of heterogeneity. A 1997 study completed by Leikin and Zaslavsky used an experimental small-group cooperative-learning setting to show using a structured setting that facilitates students' cooperative learning enables students to enhance their understanding of mathematics, establish shared understanding of mathematics, become more active learners, learn in a comfortable environment, and assist the teacher in gaining insight into their thinking. Communicative interactions between students enhance the learning experience. Leikin and Zaslavsky pointed out that, compared to student-teacher learning interactions that dominate whole class settings, student-student learning interactions tend to dominate the cooperative-learning setting. Verbal interactions are increased mainly because of the opportunity for increased student-student learning interactions. In addition, the supportive atmosphere created by the learning environment encourages students to ask for help despite their normal reluctance to do so (Newman & Goldin, 1990). Using

cooperative-learning settings promotes task-related interactions by students and promotes students' active explorations in the mathematics classroom.

Webb, Farivar, and Mastergeorge (2002) cited three conditions for learning when working in cooperative groups: (a) the student receiving help must understand the explanation, (b) the student receiving help must have an opportunity to use the explanation to solve the problem or carry out the task for him- or herself, and (c) the student receiving help must use the opportunity for practice by attempting to apply the explanation received to the problem at hand. They further explained that the level of help the student receives corresponds to the level of response from the student who needed the help which corresponds to the amount of achievement. Therefore, to benefit from cooperative learning, the learner must be an active participant in the learning process. The teacher's role becomes one of a monitor and facilitator of desired behavior in the cooperative learning groups. The teacher must structure tasks that support learning and understanding and tasks that promote working together to help each other in the group. In this manner, all students will benefit. When the students work together in a collaborative effort, they benefit from the step-by-step descriptions of how to solve problems because they are clarifying through explanations. Webb, Farivar, and Mastergeorge remarked that, this requires a reorganization of the material in their own minds to make it understandable to others which in turn enables them to develop new perspectives and recognize and fill in gaps in their own understanding.

Lotan (2003) pointed out that constructivist educators agree group work is particularly beneficial when conceptual learning, problem solving, and deep understanding of content are the goals of instruction. To promote effective group work, teachers must design activities that are considered, according to Lotan, group-worthy.

Lotan described group-worthy tasks as those that are: (a) open-ended and require complex problem solving; (b) they provide students with multiple opportunities to show intellectual competence; (c) they deal with discipline-based, intellectually important content; (d) they require positive interdependence as well as individual accountability; and (e) they include clear criteria for the evaluation of the group's product. Cohen (1994) pointed out that students make their own judgments about others abilities. They are quick to conclude that some students are "smart" and others are "dumb". These perceptions lead to students creating a rigid status order in the classroom that affects participation and learning in small groups. Using group-worthy tasks that are multidimensional allows each student to shine in their own way. Cohen remarked that, this provides a more equitable learning environment that narrows the academic achievement gaps among racial and ethnic groups and social classes. Using group-worthy tasks provides students with the opportunity to work with their peers in meaningful and challenging ways. Using group-worthy tasks that have academic and social benefits contributes to a friendlier classroom and promotes a students' critical thinking skills (Lotan, 2003).

In a meta-analysis completed by Springer, Stanne, and Donovan (1999) on the effects of small-group learning in undergraduate programs in science, mathematics, engineering, and technology (SMET), they found the main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET education was significant and positive. The academic achievement of underrepresented groups and the learning-related attitudes of women, according to Springer, Stanne, and Donovan, are greatly influenced by small-group learning. In addition, they found that the amount of time spent in groups is directly related to attitudes among students in general. The more time spent in group work, the more positive the attitudes towards learning for the student.

It is studies such as the one completed by Springer, Stanne, and Donovan that will help to eventually eliminate the belief that lecture hall education-although everyone agrees it is a terrible way for students to learn-it is still the best thing anyone has yet invented (Arch, 1998).

*Collaborative learning.* When students are involved in a peer learning situation, the emphasis is on collaboration within the group. This collaboration provides opportunities for students and teachers to accomplish behavior that is productive to learning. Roschelle (1992) defined collaboration as the construction of shared meaning for conversations, concepts, and experiences. Palinscar and Herrenkohl (2002) extended this definition by attaching conditions for promoting collaboration. When working on a task, all members of the group share cognitive responsibility for the task at hand. One method of peer collaboration, reciprocal teaching (RT), was designed as an educational intervention for students who demonstrate significant disparities between their ability to decode and comprehend text. Furthermore, Palinscar and Herrenkohl stated that research from RT influenced the design of cognitive tools and intellectual roles (CTIR) which was designed to enhance students ability to engage in scientific problem solving. Using RT, students and teachers used four strategies to share responsibility for leading the discussions about text. Using CTIR, explanations of scientific phenomena are formulated using three steps that help students collaborate to derive a common focus for their interactions. Regardless of which collaborative method is used in the classroom, each share commonalties. Palinscar and Herrenkohl pointed out that, students are learning to respect each others' ideas and begin to realize the importance of the contributions of each student, thereby making the classroom environment one where both debate and consensus are welcomed.

According to Johnson and Johnson (1985) and Slavin (1989) collaborative learning requires a dynamic participation of individuals working together to construct knowledge. Keller (1983) defined satisfaction as the perception of being able to achieve success and feelings about the achieved outcomes. Use of computer-supported collaborative learning has the potential for providing collaborative learning and learner satisfaction. While Wang, Hinn, and Kanfer's (2001) study failed to detect any significant interaction between learning styles and the computer-supported collaborative learning (CSCL) program entitled Toward an Integrated Learning Environment (TILE), the results suggested that CSCL environments support diverse learning styles and provide student learner satisfaction.

By using technology as a part of student collaboration, the classroom environment can change. The students become more excited and enthusiastic about learning. In addition, the use of technology and student collaboration enables the students to transfer much needed social skills and computer applications to the workplace. Collaboration is enhanced when students are encouraged to work with each other. They learn to respect each other's opinions and take criticism, qualities they will need in the working world (Batane, 2002). If educators are to keep students interested and engaged in education, educators need to focus on student centered learning. According to the theory of constructivism, learning should be contextual; school knowledge should not be isolated facts and abstract theories, separate from the rest of the students' lives (Stice, 1990). If one were to promote the theory of constructivism, then a more student-centered approach to learning where the information being learned can be applied to situations outside of the classroom needs to take place in the classroom. The *Teachers and technology: Making the connection report* (U.S. Congress Office of Technology

Assessment, 1995) reported that students are more motivated to learn when using technology and that the use of technology helps to engage all learners of different learning styles. This is important. Students interact with content differently. Use of technology and student collaboration is one way in which teachers can ensure everyone is learning. If technology and student collaboration can help connect what the student is learning in school with what is happening outside of school, then everyone benefits.

*Peer learning.* Students learn in a variety of ways. Peer learning is a powerful tool if and when it is used correctly. Classwide Peer-Tutoring (CWPT) provides a method of allowing students to serve as tutors to help increase learning opportunities for other students. Classwide Peer-Tutoring actively engages all students in a classroom that promotes mastery, accuracy, and fluency in content learning for students (Arreaga-Mayer, 1998). In addition, according to Arreaga-Mayer CWPT uses behavioral techniques to promote acquisition of academic and social behaviors. Some of the major benefits of CWPT include early intervention, self-pacing, monitoring of students' progress, direct teaching of academic and cognitive skills, teaching of self-management, and offering positive consequences for improvement. CWPT allows for use of all learning modalities as verbal and visual explanations and modeling and practice with feedback are all a major part of the process. Greenwood, Delquadri, and Hall (1984) and Harper, Mallette, Maheady, and Clifton (1990) have completed several studies that show CWPT provides positive effects on several measures of academic achievement. CWPT offers a way to actively engage students in their own learning. In addition, Arreaga-Mayer remarked that, it offers teachers a flexible, adaptable, motivating, and cost- and time-effective approach to increasing positive academic outcomes.

Peer learning requires a major shift in focus from what is being taught to what is

being learned and requires the student to take more responsibility for their own learning (Cooper, 2002). Allowing the student greater control of their learning also provides an increased level of satisfaction for the student. Studies (Andrews, 1992; Cooper & O'Donnell, 1996) show a student has a greater sense of partnership with instructors in the learning process and an increased cognitive, social, and emotional benefit when there is direct interaction between the teacher and the student. In peer learning, the teacher models expert learning and problem-solving strategies which the student, in turn, observes and reflects upon to apply in their own setting. Heller and Hollabaugh (1992) discussed how this observe-reflect-discussion-apply pattern promotes gains for students of all ability levels, especially in analysis and solution of problems. Cooper stated that, key elements in creating a match among goals, outcomes, and implementation strategies are the classroom environment and the place of technology within the environment, the stance of the teacher, and the choice of task and dialogues. By paying careful attention to these aspects of the learning process, peer learning can be a powerful instructional tool.

During the last decade, it has become more common for academic standards to focus on promoting higher order thinking skills (Richardson, 2003). One method that is available is the peer learning approach, Guided Reciprocal Peer Questioning, whereby peer learning can be structured to ensure that learners engage in high-level cognitive processing (King, 2002). King asserted that students may improve their thinking and learning by repeatedly thinking about their thinking, which presumably promotes students' awareness of their thinking processes. By using peer learning tasks that demand a higher, more complex, level of cognitive processing, students work together to solve problems, analyze and integrate ideas to go beyond presented material to build new knowledge, make group decisions, use peer assessment of learning and engage in peer

tutoring. This type of interaction goes beyond the material presented to the acquisition of, and use of, new knowledge.

In addition, when teachers consistently and clearly model reciprocal teaching methods, students' dialogues will mirror that of their teachers. This leads to deeper insight of concepts and a higher rate of comprehension (King & Parent-Johnson, 1999). According to King and Parent-Johnson, Palinscar and Brown developed one of the most successful and widely researched approaches of instruction and guided practice for content literacy, reciprocal teaching (RT). According to Vygotsky (1978) a facilitator's role is to lead a dialogue in order to scaffold learning. King and Parent-Johnson stated that, in RT the teacher and the students each take turns assuming the role of facilitator. Using RT strategies enables students to demonstrate collaborative efforts, which enable them to build understanding. One form of evidence that students are constructing meaning is their engagement in meaningful dialogue. Not only does RT enable the student to construct meaning, it also enables them, through their group interactions, to become aware of the importance of peer feedback and support. There are four cognitive strategies in RT: predicting, questioning, clarifying, and summarizing. According to Palinscar and Brown (1986) each of the four strategies promotes both comprehension monitoring and understanding. Using RT in the classroom is one method of incorporating successful constructivist activities that enable the student to engage in meaningful learning.

As technology becomes more prominent in the classroom of the 21st century, teachers and students must learn to utilize the technological tools available. Using computer-based instruction (CBI) and classwide peer tutoring (CWPT) together is one way to successfully integrate an instructional alternative to achieve specific individual

and classroom goals. Mercer (1992) defined peer tutoring as a dyad, or the pairing of two students, to enhance and extend academic instruction. Pairing an average to above-average student with a lower achieving student allows for demonstration and modeling by the tutors. This provides a structured learning environment that encourages active student participation. But successful integration of CBI and CWPT necessitates teacher training, planning, and role flexibility, and the use of an instructional arrangement to facilitate integration (Smith, 1997). According to Greenwood, Delquadri, and Carta (1988) there is an impressive research base that supports Light and Mevarech's (1992) assertion that integrating CBI and CWPT not only facilitates academic responding and learning, it fosters self-esteem, social development, and problem-solving skills. Therefore, schools will need to provide or teachers will need to seek instruction on how to select software that focuses on appropriate matches between the lessons' instructional objectives and implementation of CWPT.

*Teaching methods and learning styles: Teaching methods.* The constructivist theory maintains that students learn best by taking in information from the world and constructing their own meaning from the experience as opposed to someone telling the students bits of information. Instead of lecturing and telling students the expected answer, the teacher acts as a mentor and asks questions to help them discover the answer themselves (Sprague & Dede, 1999). Using constructivist theories, teachers encourage student inquiry and allow student responses to drive the lesson plans, modifying as they go, if needed. Constructivist classrooms involve a collaborative environment that encourages the knowledge construction needed for more lasting learning (Jonassen, 1996). To someone unfamiliar with a student-centered approach to learning, the classroom may appear chaotic. But, as Sprague and Dede pointed out, this does not mean

students are not learning. Such activities are often more motivating and interesting to students because they are learner-focused and authentic, encourage critical thinking, and create knowledge that is lasting, transferable, and useful (Carr, Jonassen, Litzinger, & Mara, 1998). This seemingly unstructured approach to teaching and learning is anything but. Yet it continues to be the stumbling block for most educators. Sprague and Dede stated that teachers who believe that learning should be interesting and meaningful for students need to move past their concern that constructivist instruction is not teaching.

Educational change requires teachers to understand themselves and to be understood by others. Lortie's study (1975) found that teachers are not sure whether they have made any difference at all in a student's education or lack thereof. This uncertainty should be a major factor in changing the way educators educate. This requires a rethinking of the way we teach, a rethinking of the traditional classroom, and a rethinking of student outcomes. This could mean a radical change in the culture of schools and the conception of teaching as a profession. How teachers view their roles as teachers influences how they teach. Using the learning theory that a constructivist teacher uses requires a shift in how a teacher views their role in the classroom. Teachers working with other teachers at the school and classroom levels is a necessary condition for improving practice (Fullan & Stiegelbauer, 1991b).

Addressing the different learning styles of students can result in improved practice and attainment of skills. Results of a study completed by Baker and Beisel (2001) suggested that a variety of instructional techniques should be utilized in order to address the different learning styles of students. While the authors used the concept of average as their basis for this study, the findings can be generalized to other mathematical concepts where the usual mode of instruction is presentation of an algorithm. The lecture

and/or worksheet approach is used too often in the mathematics classroom when learning and teaching mathematical concepts. The traditional form of instruction, lecturing, does not provide the benefits of a variety of teaching styles. While findings of Baker and Beisel suggested some advantage in the use of a visual instructional style, maturation should also be considered when calculating performance improvement of the students. It is possible that older students will benefit more from a more advanced topic than the younger students, due to the ability to process the information in different ways. Other benefits of addressing teaching methods and learning styles include the benefit of reflection on teaching practices, the use of otherwise untried methods of teaching a concept (i.e. technology use) and the insights that the teacher obtains in how best to present a mathematical concept to students.

The National Research Council (NRC) (Kilpatrick, Swafford, & Findell, 2001) examined all types of research on mathematics learning in order to offer recommendations to help students improve their learning. According to Baker, Gersten, and Lee (2002) one of the recommendations made by the NRC was to design instruction using sound research to better help low achieving students succeed in mathematics. In addition, Baker et al. (2002) stated that teachers should play a more active instructional role in helping their students build mathematical proficiency than they currently do, as recommended in the report. Baker et al. synthesized 15 research studies on the effects of interventions to improve the mathematics achievement of low achieving students. Low achieving students were identified by their standardized test scores or by their placement in remedial mathematics classes. Results indicated that different types of interventions led to improvements in the mathematics achievement of low achieving students. According to their analysis, peer-assisted learning interventions, use of explicit

instruction in mathematics, providing parents with feedback on students accomplishments, and providing teachers and students with student performance data all had positive effects on student achievement. Furthermore, the NRC suggested that to engage students in the mathematical work, maintain their focused involvement in it, and help them take advantage of instruction to learn, active instruction plays a critical role. One way to achieve active involvement is by using multiple instructional methods. Ball, Lubienski, and Mewborn (2001) pointed out that having a strong background in mathematics is not as important as knowing how to teach math well to students with differing abilities. If students, of all abilities, are to succeed in mathematics, teachers must be open to trying instructional practices that have been proven, through sound research, to work. Using technology might be one way to engage students in mathematical work. Butzin (2000) inferred that students learn more because they move at their own pace while using technology that involves them in interesting tasks which utilize multiple leaning styles. Cathcart, Pothier, Vance, and Bezuk (2000) believed teaching mathematics requires designing strategies and activities that will help children learn the concepts meaningfully.

McCoy (2000) completed a study on different approaches to teaching algebra. Reformers of the traditional approach emphasize access to algebraic ideas, K-12 development, and broader conceptualizations of content (Kaput, 1995). The National Council of Teachers of Mathematics (NCTM) advocates using problems that have meaning for the students. McCoy remarked that, the use of each curriculum, in varying ways, is to help the teacher encourage students to be active participants in their learning experience and to encourage students to continue in math courses.

Teaching efficacy is strongly related to the behavior of students in the classroom.

Students with behavioral difficulties impede a teacher's objectiveness and willingness to provide help to these students. According to Morin (2001), affirming a teacher's self-worth will help the teacher to be more willing to change the way he or she handles disruptive students. It is possible that cooperative learning strategies may help in this situation. When teachers create a positive climate for cooperative learning, higher achievement, higher self-esteem, improved cross-ethnic relations, peer acceptance, improved behavior, and improvement in social skills are a few of the advantages that result from cooperative approaches (Putnam, 1997). One type of a cooperative approach, the use of a question-based approach, according to Richetti and Sheerin (1999), increases the relevance for the students as they become more invested to the situation by applying their judgements and conclusions. They become more interested in their learning while becoming more effective questioners, thinkers, and learners. They learn from one another as well as from the teacher and the materials.

Educational change requires teachers to understand themselves and to be understood by others. Change cannot be an isolated event. If change is to be accomplished, everyone must be involved in the process. The latest instruction method involves computer-based instruction that emphasizes student participation. Wang, Hinn, and Kanfer (2001) completed a study on learning styles and the computer-supported collaborative learning (CSCL) program entitled *Toward an Integrated Learning Environment (TILE)*. The results suggest that CSCL environments support diverse learning styles and provide student learner satisfaction.

Whichever method of instruction is used, it must be used effectively. A good curriculum is only as good as the teacher makes it. If the teacher uses creative ideas that actively involve the students in their own learning, they will have students who are

experiencing success in mathematics. This success will lead to mastery of the concepts and a better understanding of the principles and rules of mathematics.

*Learning styles.* Studies (Dunn & Dunn, 1978; Lewis & Steinberger, n.d.) have shown the importance of addressing the use of different learning styles when presenting material to students. Teachers and administrators must teach students what they need to know in math and science as well as other subjects in order for students to be well prepared for future careers and the workforce (Nuttall & Hell, 2001). But what is the best way to do this?

There have been many theories, classified in various ways, about how children learn (Pa, as cited in Cathcart, Pothier, Vance, & Bezuk, 2000). According to Cathcart et al. (2000) these theories have a significant bearing on how mathematics is taught. Cathcart et al. enumerate learning theories discussed beginning with the late nineteenth century theory of mental discipline. According to the mental discipline theory, the mind is viewed as a kind of muscle that required a reasonable amount of exercise to keep it properly tuned. E.L. Thorndike's stimulus-response theory stated that learning occurs when a bond was established between some stimulus and a person's response to it. In the 1960's Robert Gagné published his theories that stated the principle of prerequisite learning plays an important role in a students learning situation. Finally, the authors turn to more recent theories involving the cognitive or constructivist approach and behaviorist theories. Piaget's work with developmental aspects of learning and Dienes development of concrete materials which children not only play with but also use to construct mathematical concepts underlines the importance of an active learning environment. Based on the work of the aforementioned theorists, Cathcart et al. list six major principles related to how children learn in the context of mathematics: (a) begin with concrete

representations; (b) develop understanding; (c) encourage communication; (d) make connections; (e) take time to motivate students; and (f) provide opportunities for practice. Teachers employ different models depending upon the setting and their beliefs about how children learn. According to Cathcart et al. a developmental model of teaching in which children actively engage in inquiry and investigation will be used by a teacher with a constructivist theory of learning. A diagnostic model will be used if assessing students' current level of mathematical understanding is at the core of the teaching process. A translation model is useful if the focus is on connections among various representations of a mathematical concept. An investigative model will focus on experimentation or inquiry and fits well into a cooperative learning setting. Furthermore, Cathcart et al. believed that to help children learn meaningful mathematical concepts, strategies and activities should be designed to achieve that goal. As previously stated, the job then, for teachers, is to know the students and be familiar with the subject so that the best learning environment for each child can be established.

Establishing that environment means acknowledging that students have different learning styles. According to Dunn, Beaudry, and Klavas (1989) learning style is a biologically and developmentally derived set of variables that affect the way one learns and interacts with the surrounding environment. Cohen (2001) contends that a students learning styles can be affected through external factors in the learning environment. More specifically, use of a technologically rich environment that supports a constructivist approach to learning will affect the students learning style. Cohen's study suggested that the school environment can change a students learning style. Dunn and Dunn's Learning Style Inventory (Dunn, Dunn, & Price, 1989) was administered to 66 students in the freshman class at the Academy for the Advancement of Science and Technology (AAST)

and 97 students in the freshman class at Ridgewood High School (RHS). Four of the six variables studied showed a significant change for AAST students. RHS students showed significant changes in two of the six variables. Interview questions provided insight into the students perception of technology use and its relevance to their lives. The author pointed out that the pre- and posttest shows an equal decrease in motivation for both samples and suggests that this may be the result of being a freshman in each high school, the result of the environment, or a common occurrence that is caused by entering any new high school.

Learning and performance goals influence students' attitudes towards and engagement in school work (Woolfolk, 1998). It is often believed that mathematics is considered to be a subject only for the very able (McLeod, 1992). Yates (1999) claimed that behaviors within the mathematics classroom are a direct result of these attitudes and beliefs which influence students' expectations towards mathematics, particularly in relation to failure. Furthermore, research (Bandura, 1977; Hembree, 1990; Reyes, 1984) shows that a student's level of anxiety, self-confidence, self-concept, and self-esteem is directly related to their achievement in mathematics. One study completed by Yates explored the attitudes of 243 third through seventh grade students, over a period of approximately three years, and how that attitude affects achievement in mathematics. The results indicated that there is a significant correlation between students' achievement at the beginning of the study and their optimism, pessimism and task involvement over the course of the study. In addition, achievement levels are significant when correlated with their optimism and task involvement, but not for with their pessimism. Grade level and task involvement is also correlated strongly with students' mathematics achievement. Finally, gender does not play an important part with the exception that females are more

optimistic than males throughout the study. According to Yates the regression results confirm students' optimism, pessimism and task involvement in 1993 as significant predictors of their achievement in mathematics two years later. The role of the teacher must not be lost in this discussion. Teachers hold a great deal of power when it comes to how they can make a student feel about their abilities and the work they perform in and out of the classroom. Teachers play an important role in the development of students' attitudes and motivation and must be cognizant of these contributions.

As Richetti and Sheerin (1999) pointed out, educators that assess student perspective and understanding before introducing a concept can make meaningful linkages and assess learning afterward. Constructivism depends upon listening to the student. Students who become invested are interested in seeing what really happened or in comparing their conclusions with those of others. Cooperative learning situations provide opportunities for students to be listened to and to listen to others. In addition, research by Johnson and Johnson (1989) showed that cooperative learning can cause higher achievement, more positive heterogeneous relationships, better attitudes towards teachers, higher self-esteem, greater social support, more positive psychological adjustment, more on-task behavior, and greater collaborative skills. Teachers who blend education and change will be going a long way in accomplishing some of the more complex cognitive and social educational objectives contained in the policy statements and curricula of most school districts (Fullan & Stiegelbauer, 1991a).

*Impact of better scores on students: Assessment.* According to Stiggins (1999) the history of accountability through assessment began in the 1930s with college admission testing. This led to district-wide testing in the 1950s and 1960s using norm-referenced standardized testing programs. In the 1970s statewide testing began and

developed into the 1980s national testing. The 1980s led into the 1990s and international comparison of assessment scores. Thus standardized testing has evolved into the tool that measures school effectiveness. The problem with this school of thought, according to Stiggins, is that desired school improvement cannot be produced by testing itself because the tests do not deal directly with matters of teacher effectiveness or student motivation. Furthermore, it is counterproductive to raise anxiety levels as a means of raising test scores. His suggestion is that we use assessment as a source of confidence. One method of achieving this is by using student assessment methods that involve the student in their own learning and academic success. Black and Dylan (1998) reported that consistent and sizable gains in standardized test scores are directly attributable to prior differences in teachers' classroom assessment practices. Furthermore, their studies indicated that low achieving students benefit more than other students when assessment methods are improved. In addition, Black and Wiliam cited research studies that show merely giving grades for work does not benefit the student. By using assessment methods as motivation tools, the goal then, as educators, is to garner confidence in the student that may lack such confidence and to maintain the confidence in learners from the beginning. Increased confidence in ability will result in an increased effort and the assumption that learning may just be worthwhile after all.

Unfortunately, as Hargraves, Earl, and Schmidt (2002) discussed, there is a disturbing trend for more standardized testing in the United States. In addition, many states require students to demonstrate proficiency on a standardized assessment before awarding diplomas. Teachers are feeling the stress of meeting the standards for the high stakes testing resulting in assessment practices that are easier for the teacher to grade rather than assessment practices that are more meaningful for the students. Cunningham

(1998) pointed out that teachers are encouraged to teach to the test, because the tasks for students comprise real situations that students need to master for success. But with authentic assessment teachers and students can work together. As Hargraves et al. (2002) proclaimed, educators should not cater to popular prejudices and assumptions about assessment, but rather they should deepen everyone's understanding of learning and assessment issues. Assessment should be an opportunity for teachers and students to reflect on the learning that has taken place. There are several problems that may occur with alternative classroom assessments. Stiggins (1997) mentioned that alternative assessment takes time. Linn, Baker, and Dunbar (1991) voiced concerns about reliability and validity. Earl and Cousins (1995) claimed that there is an assumption that teachers have the necessary skills to implement alternative assessment. Some educators feel as if they must entertain the students. Meier (1998) pointed out that in the endeavor to entertain and avoid boredom we miss powerful learning and clear purpose in what passes as authentic curriculum and assessment. Educators, students, parents and administration must work together to avoid the problems mentioned above.

Orfield and Kornhaber (2001) proclaimed that high-stakes testing assumes that rewards and consequences attached to rigorous tests will motivate the unmotivated to learn. However, Amrein and Berliner (2003) analyzed four standardized test measurements; the SAT, the ACT, Advanced Placement (AP) tests, and the National Assessment of Educational Progress (NAEP) for each of the 18 states that use standards-based testing and found that student learning is not increased nor is student motivation to learn. In fact, additional pressure to perform on high-stakes testing causes teachers to lose that which is so desperately needed for the low achieving students, innovative ideas and teaching methods. Classrooms that are driven by tests do not encourage the desire to

learn. Instead, they can exacerbate boredom, fear, and lethargy, and can promote all manner of mechanical behaviors on the part of teachers, students, and schools (Sacks, 1999). This notion of deciding the fate of students, teachers, and schools based on one test given on one day can lead to teaching to the test and may exacerbate the already present problem of retaining quality teachers. Perhaps it is time for policy makers to realize that high-stakes testing policies are not making the grade. Amrein and Berliner remarked that, one of the results of high-stakes testing is decreased student motivation which leads to higher student retention and dropout rates.

According to Jacob (2001) high school graduation tests were started as part of the minimum competency testing (MCT) movement in the 1970s. They are generally criterion-referenced exams that focus on basic reading and math skills. In addition, Jacob explained that proponents of such exams argue that the exams help raise achievement levels by focusing school goals and providing students and teachers with meaningful incentives. Critics respond that these tests are not only ineffective, but raise dropout rates, sacrifice higher order thinking skills, and adversely affect students of color. Several studies (Bishop, 1998; Frederiksen, 1994; Hess & Lockwood, 1986; Mangino & Babcock, 1986; Winfield, 1990) have examined the effect of MCT and student achievement with mixed results. Other studies (Catterall, 1987; Griffen & Heidorn, 1996; Kreitzer, Madaus, & Haney, 1989; Lillard & DeCicca, 2001; MacMillan, Widaman, & Hemsley, 1990) have focused on the relationship between MCT failure and school leaving. Again, the results are mixed and as Jacob states the results do not necessarily imply that the existence of the policy [MCT] will lead to higher dropout rates. In a study completed by Jacob, he attempted to analyze data from the National Educational Longitudinal Survey (NELS) on high school graduation exams and their impact on

student achievement and dropout rates. Jacob used a sample of 12,171 students when discussing state mandated graduation tests and dropout rates and a separate sample of 11,200 students who take state- and school-mandated graduation tests. Among the many results, Jacob found that there was no significant impact on 12th grade math or reading achievement when using graduation tests. In addition, the tests increased the probability of dropping out among the lowest ability students. While it is reasonable to expect graduates to perform at a minimum of an 8th grade level, the level at which most MCT measure, policy makers need to address the goals and outcomes of such tests. If research shows no appreciable gain in achievement levels for students, then what exactly is the test supposed to accomplish?

According to Johnson, Wallace and Thompson (1999) children begin school wanting to learn. Teacher approval and high expectations can promote student achievement. Just as low teacher expectations, lack of teacher approval, or overt teacher disapproval can serve as negative reinforcers, with related negative consequences on student performance. In a 1999 survey completed by Johnson, Wallace and Thompson, it was found that the quality of instruction that students receive could be the direct result of how teachers perceive their own abilities in the classroom and with how they implement assessment. When a teacher is comfortable with the classroom instruction and assessment methods, students benefit from an increased interest in instruction. According to Johnson et al. (1999) the change needed for true educational reform has advanced more than is commonly recognized. The authors proclaim one of the major findings of their study is that considerable change has occurred in the teacher-respondents' attitudes with regard to a variety of assessment-related areas. In addition this study has shown a vast difference, between the teachers and the teacher educators, in what is considered to be of importance

in regards to understanding concepts, different types of assessments and the ability to align classroom instruction with goals and objectives of performance-based assessment.

Test-based reform proponents are speaking loud and clear. Their premise is, according to Neill (2003), that focusing on a limited set of skills and facts will prepare students for further education and it will at least guarantee that teachers teach the basics and thereby initiate a positive reform process. But Neill pointed out that it is a theory based on profound misunderstandings of how humans learn. Furthermore, Shepard (2000) has shown that there is not a correlation between tests and learning. In addition, research (Bransford, Brown, & Cocking, 2000; Pellegrino, Chudowsky, & Glaser, 2001) sustains the notion that learning is better served when the student is actively engaged in the learning process. This research supports Neill's statement that curriculum and meaningful instruction is compromised by high-stakes testing. It causes students to turn off, tune out, and often drop out; induces schools to push students out; increases grade retention; propels teachers to leave; and inhibits needed improvements. Assessment that actively engages the student, provides meaningful feedback, and supports higher order thinking skills will help raise achievement without sacrificing substance.

The causes of poor performance on achievement tests are a widely discussed issue. Since most states now require some form of standardized test to be passed before a diploma is awarded, performance must be improved. Nuttall and Hell (2001) analyzed results from the Massachusetts Comprehensive Assessment System (MCAS) and found that scores indicate that low income, race, and gender do not contribute as a large proportion of variance in test scores. This study has shown that the quality of instruction needs to be re-evaluated because courses and quality of education have a strong influence on achievement scores.

Schools become effective when they organize their curriculum for teaching and learning with standards that are based on objectives that best mirror what the state, school boards, parents, teachers and students deem important for their own goals. Changing a one size fits all standards based assessment to one that is best for the individual school requires involving all interested parties. According to Sergiovanni (2000) successful schools share three characteristics: parents, teachers and students are satisfied with them; they are successful in achieving their own goals and objectives; and their graduates exhibit democratic values, attitudes and behaviors. These characteristics can be considered a measurement of what a layered approach to standards based assessment can achieve when it is used. Sergiovanni stated that a unique sense of what a school stands for and a unique commitment to this sense helps to protect and grow a school's lifeworld. His definition of lifeworld encompasses a school's local values, traditions, meanings and purposes. People make standards and not all standards are appropriate for all locations. Only by involving states, school boards, parents, teachers and students in the process can the process be truly meaningful for the school.

Reports that issue a single grade to explain achievement of a student can be unfair and misleading. Wiggins (1996) believed that a single grade hides more than it reveal. It would be more beneficial, to everyone, to give more separate grades for performances in subtopics and skills within a subject area. Changing the model we use to report and summarize performance data personalizes the report by showing specific strengths and weaknesses. Using current reporting methods does not enable parents or other interested parties, outside of the school setting, to recognize students performance progress against standards. This is typically reported on a standardized test taken once a year. But, according to Wiggins, using broad descriptors such as Basic, Proficient, and Advanced

does not provide a clear sense of just what the child can and cannot do. Wiggins suggested that using data to measure current performance against exit standards will provide information and ongoing feedback on the student, without overwhelming the parent with data. Several concerns can be addressed by providing more context in reporting. By using various performance reports that use national standards where achievements and progress are separated, the current trend of worrying more about grades than learning can be eradicated. In addition performance is separated into its many subscores. Wiggins remarked that, this allows for particular strengths and weaknesses to be more reliably identified so that improvement can be sought with a clearer focus on the problems to be solved. Assigning a single arbitrary grade for student performance does not highlight the positive or unique accomplishments of a student. Using more honest reports will provide more information for the educator, the student and the parent.

*Instructional technology use.* The way teachers are teaching and students are learning is changing. If one were to promote the theory of constructivism, then a more student-centered approach to learning where the information being learned can be applied to situations outside of the classroom needs to take place in the classroom. Considerable research has been conducted since the mid-1980s investigating the effects of small group versus individual learning when students learn using computer technology (Lou, Abrami, & d'Apollonia, 2001). In a meta-analysis of 122 studies of 11,317 learners, Lou et al. (2001) found that small group learning had significantly more positive effects than individual learning on student individual achievement, group task performance, and several process and affective outcomes. With the ratio of students to computers dropping from 125 students per computer in 1984 to the current ratio of 10 students per computer (Coley, Cradler, & Engel, 2000), computer technology (CT) has the potential to be a

powerful and flexible tool for learning (Scardamalia & Bereiter, 1996). But careful consideration must be given to the instructional strategies used. As Lou et al. pointed out, historically, the most common instructional strategy was to have students work individually at a computer. From individualized instruction with Skinner's (1961) teaching machine to computer-assisted instruction (CAI) using drill-and-practice activities in the 1970's to the resurgence of CT using microcomputer's in the 1980's, individualized student instruction has morphed into interactive hypermedia with all forms of multimedia. Use of CT in education supports constructivist concepts where peer collaboration and exposure to multiple perspectives are used. Lou et al. stated that it is important to remember that CT can be an important process in the learner's construction of knowledge. Regardless of the reasons one may implement CT in the classroom, the study completed by Lou et al. suggests that when working with CT in small groups, students in general will gain more group and individual knowledge than if they worked with CT individually. Furthermore, it suggests that old fears of social isolation can be overcome and students can collectively learn well with technology.

The *Teachers and technology: Making the connection report* (U.S. Congress Office of Technology Assessment, 1995) reported that students are more motivated to learn when using technology and the use of technology helps to engage all learners of different learning styles. Students interact with content differently. Use of technology and student collaboration is one way in which teachers can ensure everyone is learning. If technology and student collaboration can help connect what the student is learning in school with what is happening outside of school, then everyone benefits.

According to National Assessment of Educational Progress (1996) statistics, in 1996 more than 80% of the K-12 students in the United States reported using computers

for learning purposes in school or at home, though this proportion was just above 50% in 1984. Educational research on the effects of computer use in education, or more specifically, computer-assisted instruction (CAI) often produces contradictions. Bayraktar (2001/2002) synthesized research that investigated the effectiveness of CAI in science classes. Using a meta-analysis of 42 studies, she found 108 effect sizes with a 0.273 standard deviation, indicating that CAI has a small positive effect on student achievement in science education when compared to traditional instruction. In addition, computers were found to be more beneficial in student learning when used as a supplement to teacher instruction and when teacher-developed programs are used instead of commercially prepared software. Bayraktar suggested that the higher effect sizes associated with studies using simulation might be partly because simulations create a more active learning environment thus increasing student involvement and enhancing achievement. To further enhance learning, classrooms need to be provided with a sufficient number of computers and teachers need to use technology in their curriculum.

Branigan (2003) wrote a synopsis of James A. Kulik's (2002) review, titled *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. According to Branigan, the 36 evaluations focused on four types of computer applications: integrated learning systems (ILS) in mathematics, computer tutorials in science, computer simulations in science, and microcomputer-based laboratories. Kulik's study found that when used effectively, computer drills and tutorials can improve student performance in math and science. Branigan listed the results of Kulik's study in her synopsis. She stated that students who used ILS to study mathematics improved their scores by 0.38 standard deviation, or from the 50th to the 65th percentile. Notable effects on students attitudes and meaningful results on science

achievements were, according to Kulik, also found. Studies, which used computer simulations in science, found two positive effects and two negative effects. The median effect raised test scores by a 0.32 standard deviation, or from the 50th to the 63rd percentile. Of the eight studies using microcomputer-based laboratories, seven found small negative or small positive effects on student learning. One study found a very strong effect but Kulik stated that the study had a design flaw, which may have accounted for the results. While most of these studies were completed from 1990 to 2000, which may indicate that they did not use the most up-to-date technology resources, they are still a good starting point for indicating that student performance can be impacted by effective use of technology.

In another study completed by Cohen (2001), two very different freshman high school classes were compared. One high school, the Academy for the Advancement of Science and Technology (AAST), used a project-based approach to learning with a technology-rich environment. The other, Ridgewood High School (RHS), had a more traditional curriculum. In addition, students at AAST were considered above average academically. Interview questions provided insight into the students perception of technology use and its relevance to their lives. The results clearly show that technology has made a difference in the AAST student's achievement levels.

Schacter (1999) summarized several studies (Baker, Gearhart, & Herman, 1994; Harel, 1988, 1991; Kulik, 1994; Mann, 1999; Scardamalia & Bereiter, 1996; Sivin-Kachala, 1998; Wenglinsky, 1998) that analyzed the impact of educational technology on student achievement and student attitude towards learning. According to these studies, students who use educational technology improve their scores on tests therefore improving their outlook, and thusly, their attitude towards learning mathematics. Dr.

Martha Stone Wiske, co-director of the Educational Technology Center at the Harvard Graduate School of Education, (as cited in Schacter) believed a difficulty about technology and education is that technology is often thought of first and education later. Several factors must be considered if effective implementation of educational technology is to take place. The availability of the technology, the specific program being used and how it is tied to the learning objectives, the teacher's training, the amount of time spent using the program (both student and teacher), and prior skills of the students must be addressed before the program is put into place.

Educators need to determine if the specific purpose of the technology addresses the school's goals for student learning in order to answer the question of how can schools ensure that the promise that technology holds for student achievement is realized? Once this question has been addressed then the factors that need to be in place to support the effective use of technology can be considered. As noted in *Critical Issue* (North Central Regional Educational Library, 1999) to measure the effect of specific technologies on student achievement, assessment methods and instruments should be appropriate to the learning outcomes promoted by those technologies. Another factor that influences the impact of technology on student achievement is the concept that a change in classroom use of technology will also change other educational factors, such as the teacher's role in the classroom. With proper training, teachers can become more involved with the students instead of just lecturing to them. Students begin to work more cooperatively and engage in meaningful dialogue about educational subject matter. Teacher involvement plays an important role in the relationship between technology in the classroom and student achievement. To maximize students' success every teacher should have ongoing professional development to learn how to use new technology and how to transform what

they learn to meaningful instruction where students are actively involved in their learning. With increased use of technology comes an increased need for technical support. One way to help the transition to technology is to maintain an on-site technical support person who can answer questions and troubleshoot any problems that may arise with the technology. Teachers and students become frustrated when problems arise and the answer is not readily available. All of these issues are important, but through this all it should be remembered that technology should promote new learning goals and teaching strategies that are student-centered, collaborative, engaging, authentic, self-directed, and based on development of higher-order thinking skills (North Central Regional Educational Library, 1999). What is important to remember is that not all technological approaches are equally effective. There is more to using technology than just using it. Careful, well-planned instruction that allows the student to be actively involved may make the difference between just using the technology and actually learning from it.

Internet access and more constructivist teaching practices are commonly called for by national-and state level commissions and plans (Green & O'Brien, 2002). Use of the Internet can increase students opportunities to access information that might otherwise be unavailable to them. By incorporating the Internet into lesson plans, teachers provide the students the opportunity to increase their level of interest. One way to implement the practice of constructivist theories is to allow the student to become the teacher. Using the Internet as an information source, students can find information that may have been unavailable to them before and use this information to inform the teacher. With the influx of technology, staff development must address how to design assignments that will involve higher-order thinking skills and not just fact finding. Finally, students should have equal opportunities to access the Internet. Ample time

should be included in lesson plans to allow students who lack access at home the opportunity to use the Internet.

According to Peck and Dorricott (1994), technological tools can foster students' abilities, revolutionize the way they work and think, and give them new access to the world. Computer use should not be limited to creating worksheets, computing grades, and producing reports. Educators need to use technology so that both the student and the teacher benefit. Teachers can individualize instruction so that students can learn at their own pace. Teachers can provide access to technology that allows students to investigate, in more detail, complex problems that allow for more critical thinking skills. Students can use technology to enhance their writing skills, presentation skills, and tap into their artistic abilities. By use of programs, such as Excel and PowerPoint, students can use higher order thinking skills to solve problems, test solutions, and see immediate results. Using technology allows the students an opportunity to learn about cultures and countries that may appear boring in a textbook but alive with animation on the computer. This opens the student up to new and exciting experiences that otherwise may not have been available. In order to enhance the learning experience, teachers and students can and should make connections between the real world and the classroom. Technology is one way this can be easily achieved.

Pugalee's (2001) study explored how the use of technology in a constructivist environment contributed to the understanding of algebraic concepts. One tenet of the study was that technology can promote the construction of important mathematical concepts and applications. Therefore, students who experience obstacles when learning mathematics should be given significant opportunities to benefit from technology. By use of graphing calculators, students were able to explore algebraic concepts using a hands-

on approach. Pugalee remarked that, there is a need for further study of the relationship between active student participation and the role of technology in the construction and application of mathematics, especially for low achieving mathematics students. In order to ensure that the needs of the students are being met, teachers may need to examine their instructional practices. Not every student learns in the same way therefore different learning modalities need to be addressed. Mathematics is not just for the special few. Every student should be given the opportunity to become proficient in mathematics using the best method for their learning style.

Kimble (1999) cited studies (Healey, 1998; Oppenheimer, 1997; Ravitch, 1998; Salpeter, 1998; Tapscott, 1998; Wenglinsky, 1998) that present research results that indicate student achievement using technology is dependent upon how the technology is used. According to Kimble, students tend to learn more, in less time, in classes with computer-based instruction. They are more engaged and learn as much or more as from peer tutoring. Kimble listed several studies completed (Salpeter, 1998; Tapscott, 1998; Wenglinsky, 1998) which support technology's use in the classroom. They suggested that if technology is used in a grade-appropriate manner and teachers are provided with professional development that focuses on integrating higher-order skills there will be significant gains in student achievement. Yet those that make the decisions for technology integration must be knowledgeable about the use of technologies. The studies completed by critics of technology use (Healey, 1998; Oppenheimer, 1997; Ravitch, 1998) don't disagree that technology can be beneficial to student achievement, but instead they voice concern over how technology is used in the classroom and the expertise of those instructing the use of technology. Regardless of which viewpoint the researcher holds, both the proponent and the critic of technology agree that today's

technological world is ever changing. If educators are to prepare students for a more technologically advanced world, then they must continue to make the effort to keep current on instructional models that use effective skills and strategies to improve student learning.

According to Trotter (1990) large gains have been reported on standardized test scores in studies examining student learning outcomes with integrated learning systems (ILS). However, Becker (1992) completed a meta-analysis of nearly 100 studies and concluded that standardized tests provide little conclusive evidence of ILS impact on achievement. Mixed results are not new in the field of research. Van Dusen and Worthen (1995) believed that the reason research results are mixed may be due to the researchers underestimating the impact of ILS systems. According to the authors, this would explain the apparent contradiction between testimonials of ILS users and the results of rigorous experimentation. After conducting several local studies and one two-year national study, Van Dusen and Worthen concluded that if a computer-based integrated learning system (ILS) is used correctly, it has significant educational value. Use of ILS supports the constructivist view of learning by providing a learning environment where the student is actively engaged in constructing meaning and using critical thinking skills. But if ILS is to be effective, it must be implemented and used correctly. Van Dusen and Worthen believed that underutilization is a fairly pervasive and serious problem, one that undermines the effectiveness of the ILS. When used effectively, ILS increases the time-on-task for students and allows for individualizing instruction for each student. According to Van Dusen and Worthen, greater student achievement and equalization between low- and high-ability students can be attained using learning theory constructs whereby an individualized program that caters to specific learning needs is in place.

There are six key criteria schools must use to effectively implement ILS in the classroom: (a) a sound implementation guide; (b) an appropriate hardware configuration; (c) adequate time on the ILS; (d) adequate computer equipment; (e) effective ILS teaching; and (f) supportive, visionary administrators. Effectively using ILS will require time and effort on the part of the teacher. The ILS curriculum must be as familiar to the teacher as the textbook (VanDusen & Worthen, 1995). But, as Van Dusen and Worthen pointed out, this time and effort will be rewarded with a classroom that is transformed into a learning environment that results in improved student learning.

Use of technology in mathematics education should enable students to increase their knowledge of mathematics, technology, and the use of technology in various ways. According to Cantrell (2000), there are many ways technology can be used to teach math. Teachers must be creative when integrating technology with their instruction. Lack of experience should not be a factor as each lesson can be simplified until the learner becomes more proficient in using spreadsheets or word processing programs. By connecting the mathematics and technology with real-life applications, the students will enjoy the process of learning more and see a relevance to the material that they may not have seen before.

*Professional development: Teacher training.* How teachers view their roles as teachers influences how they teach. Using the learning theory that a constructivist teacher uses requires a shift in how a teacher's role is viewed in the classroom. Teachers are concerned about relegating too much power to the student. They feel as if they will lose control or not fulfil their role or worse, be seen as less effective by parents, principals, or supervisors (Sprague & Dede, 1999).

Teaching efficacy is strongly related to the behavior of students in the classroom.

Teachers can benefit from an in-service model that could provide ways to provide positive behavior support. But, unless the teacher is willing to adopt the practices being taught, the amount of change seen will be negligible. One in-service model that may help the reluctant teacher adapt to change is proposed by Dunlap, Hieneman, Knoster, Fox, Anderson, and Albin (2000). This model discussed three theories of why teachers may be unwilling to support a positive behavior support program for disruptive students.

Understanding teaching efficacy, attributional theory, and a change theory that involves a commitment to change can help the classroom teacher realize that disruptive students can change with positive behavior support. In order to implement these changes, the teacher must be willing to adopt the practices discussed. An impediment to this adoption is the negative attitude that teachers display when presented with the challenge of teaching the disruptive student. The disruptive student can account for some of the job-related stress, burnout and fear that some teachers experience. In addition, the teacher may fear that adopting the practices proposed by the Dunlap et al. (2000) in-service model may result in the placement of a greater number of students with behavior problems in the teacher's classroom. Implementing any change can be difficult, a challenge even, but change can be for the better.

When the principal involves teachers in student learning and exhibits a willingness to involve others in a commitment for change, positive outcomes for the school, teachers, and the students can happen. As Fullan (2002) stated, the goal is to coherently and selectively innovate, not innovate the most. Educators need to work together. Fullan believed that effective school leaders are the key to large-scale, sustainable education reform. Research completed by Newmann, King, and Youngs (2000) found that principals focused on the development of teachers' knowledge and

skills, professional community, program coherence, and technical resources affected instructional quality and corresponding student achievement. To become what Fullan called a Cultural Change Principal school leaders must be focused on moral purpose, understand change, improve relationships, create and share knowledge and forge coherence. At the heart of effective leadership is the creating and sharing of knowledge. Relationships within the school community must allow the sharing of knowledge if growth is to be obtained. The Cultural Change Principal demonstrates that learning never ends and encourages inquiry among the staff. Fullan stated that, to implement change, one must understand it. To understand it, effective leaders should involve teachers in assessing and finding collective meaning and commitment to new ways. The effective leader understands that change will not always be smooth and addresses the concerns of those that speak out. The effective leader also understands that resistance to change can be overcome by working with people but there is no step-by step shortcut to transformation. It involves the hard, day-to-day work of reculturing. Instructional leadership must play a central role in increasing student learning but the teaching profession must support it.

In a nation that is undergoing a reform agenda that requires policy changes to be enacted where students and teachers will value knowing why and how to learn educators must embrace new classroom roles and expectations (Darling-Hammond & McLaughlin, 1995). The death by ditto days must be abolished. Teaching for understanding must become the norm. In order to implement these changes, Darling-Hammond and McLaughlin stated that professional development needs to provide occasions for teachers to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy, and learners. New policies need to be incorporated into existing

policies so resulting curriculum and pedagogy will be compatible with the reform agenda. Pre-service education, in-service education, and continuing education should include cooperative opportunities for teachers to share and engage in meaningful learning. Educators must be involved with professional communities and collaborations with the local community on behalf of the children they teach. Darling-Hammond and McLaughlin stated that, habits and cultures inside schools must foster critical inquiry into teaching practices and student outcomes. Changing policies that support teachers' learning will require a hard look at existing policies. First, according to Darling-Hammond and McLaughlin, policy must create significant professional roles for teachers in many areas of practice. Second, funding must be directed to those components of a professional infrastructure that support teacher participation and learning. Third, policy supports must focus on stimulating the environment that nurtures high-quality learning communities of teachers. Policy makers and educators must keep in mind that the end result of any type of change must support student and teacher learning.

Any amount of change requires planning on the teacher's part that can be, at first, quite demanding. The teacher must develop the activities, coordinate the activities, and evaluate the effectiveness of the process. The vision of practice that underlies the nation's reform agenda requires most teachers to rethink their own practice, to construct new classroom roles and expectations about student outcomes, and to teach in ways they have never taught before (Darling-Hammond & McLaughlin, 1995). Allowing the teachers to make the leap from theory to accomplished practice, supporting teacher inquiry and collaboration, and investing in an environment of support, professional growth will be sustained and students will maximize achievement.

*Curriculum change.* The daily demands of teaching provide little time for much

needed planning, collaboration with other teachers, thinking and rewards for the teacher. Change is needed because many teachers are frustrated, bored, and burnt out (Fullan & Stiegelbauer, 1991b). As Fullan and Stiegelbauer pointed out, teaching, in and of itself, asks a lot of teachers in terms of daily maintenance and student accountability without giving back the time needed for planning, constructive discussion, thinking, and time for composure. If we are to keep the one-third to one-half of new teachers that leave the profession by the time they reach the seventh year of teaching (Metropolitan Life, 1985) then teachers must become continuous learners in a community of interactive professionals. This could mean a radical change in the culture of schools and the conception of teaching as a profession. Fullan and Stiegelbauer proclaimed that, teachers working with other teachers at the school and classroom levels is a necessary condition for improving practice.

Bersin (2002) quoted T.S. Eliot as saying, “Only those who risk going too far can ever really find out how far they can go” (p. 13). Bersin is indeed trying to go far by implementing his *Blueprint for Success* – an instructional reform designed to improve the performance of students, especially those in the bottom quartile of achievers. As he so eloquently put it, in his comments to the San Diego City Schools (SDCS) Board of Education, he was hired to be an agent of change and not a caretaker. The notion of holding every child to high standards is not a new one, but Bersin has added a new twist to it. The *Blueprint for Success* recognizes that the only relationship that counts is between the teacher and student in a classroom. Yet teachers, staff, students, parents and community leaders must all work together in an environment that encourages education. By recognizing that the world of teaching and learning is changing dramatically, we then recognize that teachers must have regular access to today’s cutting-edge instructional

techniques and investments in staff training and enhanced learning materials must be made available. Bersin remarked that educational reform requires every stakeholder to be pulling in the same direction.

Johnson, Wallace and Thompson (1999) completed two surveys designed to gather information on teachers' attitudes toward curriculum change and reform. The surveys were administered to 53 middle school mathematics teachers during a 10-day summer in-service workshop and 19 middle school mathematics teachers and 18 university-based school of education faculty members who attended a one-day professional development workshop. The authors found that the quality of instruction that students receive can be the direct result of how teachers perceive their own abilities in the classroom and with how they implement assessment. The implementation of school reform can influence a teacher's way of thinking and teaching. In this study, the teachers have accepted school reform. This acceptance gives encouraging signs that teacher's attitudes toward change are, well, changing. In addition, another encouraging result of this survey was the finding that teachers from different areas worked well together suggesting that teachers who volunteer for further classroom training may be the ones who stay in the teaching profession. Results of this type are important for educational reform. It is only by knowing what works best that educators can implement change in student instruction that results in positive achievement for both the teacher and the student.

Restructuring is not a mere buzzword, but a call for getting the policies and resources of schools to align with the missions and purposes (Wiggins, 1996). Schools become effective when they organize their curriculum for teaching and learning with standards that are based on objectives that best mirror what the state, school boards,

parents, teachers and students deem important for their own goals. Changing a one size fits all standards based assessment to one that is best for the individual school requires involving all interested parties. Only by involving states, school boards, parents, teachers and students in the process can the process be truly meaningful for the school.

### *Summary*

The literature review established the importance of constructivist teaching strategies to increase student achievement in the classroom. The theoretical perspectives of Piaget and Vygotsky were examined in the context of cooperative learning, collaborative learning, peer learning and the use of technology in the classroom. In addition, approaches to constructivist teaching strategies using various teaching methods that address learning styles was discussed in the context of teacher training and curriculum change.

The literature suggests that teaching methods and learning styles play an important role in learning . By using constructivist theories in the classroom, teachers may be able to address the different learning styles of students. By addressing the different learning styles of students, students can actively engage in inquiry and investigations that enable meaningful learning.

Furthermore, methods of assessment were discussed. Assessment can be an opportunity for teachers and students to reflect on the learning that has taken place. The use of a single test on a single day may not provide a complete picture of a students capabilities. By using educational technology students and teachers may benefit from on going assessment where students attitudes are more positive. Using educational technology may motivate the student and in turn enhance their self-esteem. They may become independent learners and develop better critical thinking skills. This is due, in

part, to the constructivist approach that technology use invites.

By listening and communicating with their peers, learning activities help to increase academic skills and to promote a deeper level of understanding of the subject matter. When learning is interesting, engaging, and meaningful to the students, effective learning takes place. Providing professional development in constructivist teaching strategies that address teaching methods, learning styles and assessments can allow reflection on teaching practices and insights into how best to present a mathematical concept to students.

Educators can make learning more meaningful for students thus improving mathematics outcomes for high school students by drawing from constructivist teaching strategies.

### Chapter 3: Anticipated Outcomes and Evaluation Instruments

#### *Goal*

The goal for this applied dissertation was that 11th and 12th grade students will perform at the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam.

#### *Expected Outcomes*

The following outcomes were projected for this applied dissertation:

1. Scores from the state exit exam will indicate that there will be an improvement so that 10 of 47 students who are repeating the test did not meet the standard score in mathematics.
2. Scores from a basic skills, in-class achievement test will indicate an improvement so that no more than 15% of the students will not meet the predetermined standard score in mathematics.
3. Classroom grades, in mathematics, of students who did not meet standards on the mathematics subtest will be at or above the 85% mark.
4. Informal interviews with teachers will indicate an improvement in student motivation that will positively affect student performance.

#### *Measurement of Outcomes*

*Outcome 1.* Students scores from the state-mandated exit exam were obtained from their student records in guidance to measure Outcome 1. Each students scores have a sub score of areas below standard in mathematics. These scores were used for individualizing each students instruction in the computer lab (called the CCC lab at the school) and for matching students together with strengths and weaknesses for peer-assisted instruction and group learning (one-on-one tutoring matched a student showing a

strength in a sub skill with a student showing a weakness in the same sub skill). Then, comparison of scores from the state mandated exit exam given at the end of this program was done to determine whether outcome 1 had been met.

*Outcome 2.* To establish a baseline score for improvement, an in-class achievement test was administered to each student as a pretest. This achievement test was a practice exit exam test with questions worded similar to what is tested on the actual state mandated exit exam test. A posttest of the same format was given so comparison of the scores could be made. In addition, comparison of the pre and posttest scores helped to determine if outcome 2 had been met.

*Outcome 3.* To allow students to see direct results of their achievement when they use constructivist strategies to learn, class grades in mathematics for each student were obtained from the current mathematics teacher at the start of the program and at the end of the program for comparison. In addition, comparison of the grades helped to determine if outcome 3 had been met.

*Outcome 4.* To determine if students prefer the peer-assisted learning approach and to determine their attitude towards learning mathematics using constructivist-learning methods, a self-made questionnaire (see Appendix) was administered at the end of the program. In addition, informal interviews with teachers were held to determine if improvements in student motivation had occurred. This showed whether or not outcome 4 was met. The questionnaire was chosen because it would provide a sense of anonymity to the students who would then give more honest answers. Informal interviews with the teachers were used because it was judged to yield the most accurate information about the students.

*Mechanism for Recording Unexpected Events*

A record was developed for each student where progress reports from the computer-assisted instruction as well as notes on successes and drawbacks of implementation were recorded. In addition, the teacher had weekly conferences with individual students involved in the peer-tutoring program and small group instruction. Information from the records has been incorporated in this applied dissertation.

## Chapter 4: Solution Strategies

### *Discussion and Evaluation of Solutions*

The problem to be solved in this applied dissertation is that 11th and 12th grade students perform below the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam.

Topic areas researched which offer the best avenues for solutions included constructivist pedagogy, learning strategies, students' attitudes towards and engagement in school work, use of technology as an instructional tool and meaningful professional development.

When examining the theories of Vygotsky and Piaget, sometimes it may be difficult to separate the two. Lotan (2003) pointed out that constructivist educators agree group work is particularly beneficial when conceptual learning, problem solving, and deep understanding of content are goals of instruction. Constructivist ideas of learning for knowledge construction were used in this program. It included peer learning, peer collaboration, cooperative learning, and use of technology to construct meaningful learning for the student.

Some research indicates that when students create their knowledge based on interactions with their environment and with other people, academic skills increase and a deeper level of understanding of the subject matter takes place (De Lisi, 2003; Draper, 2002; Sprague & Dede, 1999). Other research indicates that different types of interaction facilitate different kinds of learning (Hyerle, 1996; King, 2002). Therefore the learning approach a teacher selects should match the requirements of the learning task. In order to offer recommendations to help students improve their learning, instruction was designed using sound research to better help low achieving student succeed in mathematics.

The National Research Council (NRC) (Kilpatrick, Swafford, & Findell, 2001) examined all types of research on mathematics and suggested that to engage students in the mathematical work, maintain their focused involvement in it, and help them take advantage of instruction to learn, active instruction plays a critical role. One way to achieve active involvement is by using multiple instructional methods. One instructional method that was used in this project was to engage students in mathematical work by using technology. Butzin (2000) inferred that students learn more because they move at their own pace while using technology that involves them in interesting tasks which utilize multiple learning styles. This method was chosen because the writer searched for methods that would involve the student in their own learning while improving their mathematical skills.

Other methods that are used include peer learning or peer collaboration and cooperative learning. Student involvement in their own learning was strongly urged. Springer, Stanne, and Donovan (1999) found that the more time spent in group work, the more positive the attitudes towards learning for the student. However, Webb, Farivar, and Mastergeorge (2002) cautioned that to benefit from cooperative learning, the learner must be an active participant in the learning process. This writer believes, based on the research, that the benefits of peer learning and cooperative learning are ideal for helping the mathematics student increase their proficiency level in mathematics. When teachers create a positive climate for cooperative learning, higher achievement, higher self-esteem, improved cross-ethnic relations, peer acceptance, improved behavior, and improvement in social skills are a few of the advantages that result from cooperative approaches (Putnam, 1997). In addition, Woolfolk (1998) suggested that learning and performance goals influence students' attitudes towards and engagement in school work.

Furthermore, research (Bandura, 1977; Hembree, 1990; Reyes, 1984) shows that a student's level of anxiety self-confidence, self-concept, and self-esteem is directly related to their achievement in mathematics. The writer met with the students to discuss the learning strategies with them and to familiarize them with and make them comfortable with the process of constructivist ideas.

In addition to the aforementioned methods, computer technology (CT) has the potential to be a powerful and flexible tool for learning (Scardamalia & Bereiter, 1996). Use of CT in education supports constructivist concepts where peer collaboration and exposure to multiple perspectives are used. According to Trotter (1990) large gains have been reported on standardized test scores in studies examining student learning outcomes with integrated learning systems (ILS). But Becker (1992) completed a meta-analysis of nearly 100 studies and concluded that standardized tests provide little conclusive evidence of ILS impact on achievement. However, *The Teachers and technology: Making the connection report* (U.S. Congress Office of Technology Assessment, 1995) reported that students are more motivated to learn when using technology and the use of technology helps to engage all learners of different learning styles. Furthermore, Bayraktar (2001/2002) completed a study that suggests computer-assisted instruction (CAI) has a small positive effect on student achievement in science education when compared to traditional instruction. Computers were also found to be more beneficial in student learning when used as a supplement to teacher instruction. Taking these findings into consideration, CAI was incorporated as a supplement to teacher instruction and peer collaboration activities.

Constructivist strategies were implemented in the classroom enhanced with technology use to improve student's mathematical skills. A shift in focus from what is

being taught to what is being learned must take place (Cooper, 2002). Ideally, educators can make learning more meaningful for students thus improving achievement levels by drawing from constructivist teaching strategies. By listening and communicating with their peers, learning activities help to increase academic skills and to promote a deeper level of understanding of the subject matter. To facilitate this type of learning, educators need professional development which, according to Darling-Hammond and McLaughlin (1995) provides occasions for teachers to reflect critically on their practice and to fashion new knowledge and beliefs about content, pedagogy, and learners. Yet Fullan and Steigelbauer (1991b) pointed out, teaching, in and of itself, asks a lot of teachers in terms of daily maintenance and student accountability without giving back the time needed for planning, constructive discussion, thinking, and time for composure.

#### *Description of Selected Solutions*

Research (Springer, Stanne, & Donovan, 1999) finds that academic achievements of some students are greatly influenced by small group learning. These groups were formed based on previous exit exam sub scores in mathematics. Students were matched together with strengths and weaknesses for peer-assisted instruction and group learning (one-on-one tutoring matched a student showing strength in a sub skill with a student showing a weakness in the same sub skill).

Educational technology was used to help motivate the student and in turn enhance their self-esteem. In addition, this helped students and teachers benefit from on going assessment where students attitudes are more positive. Van Dusen and Worthen (1995) suggested that greater student achievement and equalization between low- and high-ability students can be attained using learning theory constructs whereby an individualized program that caters to specific learning needs is in place. Each student

used computer-assisted instruction that had been individualized to their specific needs. Assessment of instructional areas was accomplished using scores from the last administered state exit exam. This helped students and educators determine what skills were below standard and could be remediated to be at standard or above. Outcome assessment is accomplished by using pre- and posttest scores from an in-class achievement test that established which students are meeting the predetermined standards score in mathematics. Also, examination of class grades, in mathematics, allowed students to see direct results of their achievement when they used constructivist strategies to learn. The results of informal interviews with teachers allowed educators to examine the constructivist strategies' ability to improve student motivation and to positively affect student performance.

#### *Report of Action Taken*

During the first month of implementation, approval was obtained from the selected class teacher (the teacher of the class for students scoring below standard on the mathematics subtest of the exit exam) and the Principal for the project. In addition, the project was explained to the class of students and a letter was sent home to the parents explaining the project. Furthermore, arrangements were made for use of the computer lab (called the CCC lab at the school) on Thursdays with the Assistant Principal, who is responsible for scheduling use of the lab. The plan was implemented for a period of 16 weeks.

During the second week previous exit exam scores of students were obtained from their records in guidance to identify what skills each student was below standard on. In addition, class grades, in mathematics, for each student from their current mathematics teacher was documented for comparison of their grade at the end of the program. This

allowed the students to see direct results of their achievement when they use constructivist strategies to learn.

An in-class achievement test was administered as a pretest to the class to establish a baseline score for improvement. This achievement test was a practice exit exam test with questions worded similar to what is tested on the actual state mandated exit exam test. A record was made for each student that included exit exam scores in mathematics, pre- and posttest scores, class grades in mathematics, and CCC lab results.

Using the sub-scores from the students records as an indicator of what skills needed to be improved, each student's computer-assisted instruction was individualized according to their specific needs. In addition, the sub-scores helped to identify which students to match together for one-on-one tutoring. A student showing strength in a sub skill was matched with a student showing a weakness in the same sub skill. Furthermore, during this second week, all approvals from the class teacher, Principal, and parents were documented.

During the third week, students were explained the procedures for CCC and for peer-assisted instruction. Peer learning is a powerful tool if and when it is used correctly. To ensure that the students understood the ideas behind this constructivist approach, the teacher modeled expert learning and problem-solving strategies which the student, in turn, observed and reflected upon for application in their own setting. It was explained that the student had greater control of their learning using this process. With this in mind, the students worked together to solve problems, analyze and integrate ideas that went beyond presented material to build new knowledge, made group decisions, used peer assessment of learning and engaged in peer tutoring (King, 2002). This type of interaction goes beyond the material presented to the acquisition of, and use of, new

knowledge.

Computer lab instruction began where each student worked on the individualized lessons for them for 85 minutes of the class period. The class period is 90 minutes, therefore five minutes of the class time was allowed for students to arrive at the CCC lab and begin their lessons. The procedures for accessing the program were explained to the students before they began the CCC lab instruction. The program has a skills assessment at the end of each unit. If the student scored at the 75% mark or above they are considered to have mastered that skill and advanced to the next skill in their program. If the student scored below the 75% mark, they were given additional remediation in that skill until they achieved at least 75% on the skills assessment at the end of the unit. The program also has a communication tool whereby students can send the teacher a message about certain problems for additional help. The teacher addressed each of these as needed.

During each subsequent second and third week, students worked on peer-assisted instruction for the 90 minute class period. Peer-assisted tutoring partners were changed every two weeks so that students could begin working on the next skill as deemed appropriate by their exit exam scores in mathematics

During each subsequent second week students also worked in cooperative learning groups. Cooperative learning groups were formed according to low scoring sub-skills. Each group completed an activity based on a basic skill. For example, one group worked on a fraction activity while another group worked on a decimal activity. Students completed the activity within the 90 minute class period. Teacher acted as mentor. At the end of the activity, students shared their results with the rest of the class. These groups changed each time an activity was completed.

Reports of CCC lab work were printed the second and fourth week of each month and documented in the student's record. This enabled the teacher to monitor students progress and make adjustments as needed. During the first week of the third month, teacher met with each student individually to discuss progress as evidenced by CCC lab reports.

In order to determine if students prefer the peer-assisted learning approach and to determine their attitude towards learning mathematics using constructivist-learning methods, a self-made questionnaire was administered (see Appendix) to the class. The questionnaire was administered at the beginning of the class during the third week of the final month. The questionnaire contained 10 questions using a Likert scale. The questions were developed from a review of current literature and other questionnaires. Validity, as stated in Gay and Airasian (2000), is the degree to which a test measures what it is supposed to measure. The questionnaire used in this program contained high face validity. In addition, informal interviews with the math teachers of the students in this program were held to determine if improvements in student motivation had occurred for students in this program.

During the final week of month four, and of the program, an in-class achievement test, similar to what is tested on the actual state mandated exit exam test, was administered as a posttest to the class to establish if students improved their scores in basic math skills. In addition, class grades, in mathematics, for each student, were obtained from their current mathematics teacher for comparison with the beginning class grade. Final reports were printed from the CCC lab showing the progress for each student.

Results were documented in the students' record. The teacher met with the

students individually to discuss the results of the CCC lab, posttest and class grades. The data was then analyzed for the purpose of reporting the results of this applied dissertation intervention.

An unexpected snow storm altered the original calendar plan slightly. Due to the storm, school was not held on one of the days that the students were to report to the CCC lab. Teacher simply scheduled the students for another day during the week that they returned to school. This rescheduling did not have an effect on the reports or the classroom procedures used during this implementation.

## Chapter 5: Results

### *Results*

The problem to be solved in this applied dissertation was that 11th and 12th grade students perform below the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam. The goal for this applied dissertation was that 11th and 12th grade students would perform at the state-mandated levels of proficiency in basic skills in mathematics on the state exit exam. Many topics were researched for this dissertation, however, the most relevant insights concerned theoretical perspectives, teaching methods, learning strategies, and the impact of better scores on students.

Three outcomes were projected for this applied dissertation:

1. Scores from the state exit exam will indicate that there will be an improvement so that 10 of 47 students who are repeating the test did not meet the standard score in mathematics.

This outcome was met.

The target group was decreased by thirteen students during the applied dissertation period, which left 34 students in the group of students who are repeating the test. The thirteen students either withdrew from school or did not repeat the test at the given time. Examination of the scores on the repeated state mandated test indicated that five of ten seniors met the standard for the math portion of the exit exam and 21 of 24 juniors met the standard.

Of the 34 students who repeated the math portion of the test, 23 of the students were used as the sample for this applied dissertation. This was the number of students that were already enrolled in a class specifically for remediation of basic skills to help pass the math portion of the state mandated exit exam. Of those 23 students, 21 met the

standard.

2. Scores from a basic skills, in-class achievement test will indicate an improvement so that no more than 15% of the students will not meet the predetermined standard score in mathematics.

This outcome was not met.

An analysis of the pretest and posttest scores was completed to determine if the students showed improvement. While an improvement was made, more than the benchmark 15% of students did not meet the predetermined standard score in mathematics. 35% of the students scored below the predetermined standard score in mathematics.

3. Classroom grades, in mathematics, of students who did not meet standards on the mathematics subtest will be at or above the 85% mark.

This outcome was not met.

An analysis of the sample group's classroom grades showed that 48% of students who did not meet standards on the mathematics subtest had classroom grades, in mathematics, at or above the 85% mark.

4. Informal interviews with teachers will indicate an improvement in student motivation that will positively affect student performance.

This outcome was met.

Before this applied dissertation was implemented, teacher observation revealed high school students did not demonstrate sufficient motivation to master grade-level basic skills concepts in mathematics. During the implementation period, teacher observation revealed that high school students became more actively participatory in the constructivist-learning program thereby enhancing their motivation and ultimately

performing better on basic skills concepts in mathematics. Teacher observation revealed that students were engaged in more purposeful interactions and stayed on task more often than before the program. Furthermore, a self-made questionnaire was administered (see Appendix) to the students in the program that revealed that 18 of 23 students liked working with their peers and liked working in cooperative groups. Of the remaining 23 students, 3 were ambivalent and 2 did not like using cooperative group work and peer assisted tutoring. The score of liked or agreed with was assigned to a response of one or two; a score of ambivalent with a response of three or four; and a score of disliked or disagreed with a response of five. In addition, 18 of the 23 students responded that working with their peers and working in cooperative groups made learning easier. Of the remaining 23 students, 2 were ambivalent and 3 did not feel it made learning easier. Surprisingly, when asked if using the CCC lab made learning easier, 4 of the 23 students agreed, 9 were ambivalent, and 10 disagreed. Furthermore, 3 students liked working in the CCC lab, 11 were ambivalent, and 9 did not like working in the CCC lab. When comparing whether the students liked math at the beginning of the program versus at the end of the program, 2 students changed from being ambivalent to liking math. There were 7 students who said they did not like math at the beginning nor at the end of the program. When asked if they felt better about learning using the strategies in the program 6 replied that they did, 11 were ambivalent, and 6 replied that they did not. In addition, 5 agreed that they would like to use constructivist activities in other classes, 12 were ambivalent, and 6 disagreed. Finally, when asked if they felt their feedback was important to the teacher, 12 replied that it was, 9 were ambivalent, and 2 did not.

### *Discussion*

It was found that the applied dissertation program utilizing constructivist

teaching strategies to improve mathematics outcomes for high school students was effective in two of the four identified outcomes. The program was effective in improving the scores of students repeating the state mandated exit exam and improving student motivation, however, the program was less effective in improving in-class achievement test scores so that no more than 15% of the students did not meet the predetermined standard score in mathematics. Nor was the program effective in improving classroom grades, in mathematics, of the students in the program. None-the-less, the pre- and posttest data did show an improvement for 91% of the students after implementation of the applied dissertation program. The format of the program was well received by the students and students became more actively participatory in the constructivist-learning program thereby enhancing their motivation. To determine if students prefer the peer-assisted learning approach and to determine their attitude towards learning mathematics using constructivist-learning methods, a self-made questionnaire (see Appendix) was administered at the end of the program. In addition, informal interviews with teachers were held to determine if improvements in student motivation had occurred. The questionnaire was chosen because it would provide a sense of anonymity to the students who would then give more honest answers. Informal interviews with the teachers were used because it would yield the most accurate information about the students.

Several conclusions may be reached from the results of this applied dissertation program and are explored in the following discussion. In addition, some plausible explanations for outcomes not being met are examined.

The first outcome that was met was an improvement in the number of students that met the standard score in mathematics for the state exit exam. It is cautioned however, this improvement may have occurred without the program due to the class the

students were enrolled in to help with their basic skills. While it is certainly a positive outcome to have the student scores improve, it is unclear if the scores actually improved due to the program or to the class. The literature suggests that the constructivist teaching approach appeals to a student's interests and development of reasoning. This approach is an instructional factor in the quality of student learning. Therefore, it would be easy to say that scores improved because of the approach used in the classroom. But without further research, this writer hesitates to attribute the improvement to any one thing. Instead, this writer suggests that one may imply that academic achievement was impacted due to the program.

The second outcome called for an improvement so that no more than 15% of the students would not meet the predetermined standard score in mathematics. The results showed that this outcome was not met. The results showed 35% of the students scored below the predetermined standard score in mathematics. However, the literature suggests that assigning a single arbitrary grade, such as a standardized test score, for student performance does not highlight the positive or unique accomplishments of a student. Therefore, when analyzing pretest and posttest scores, it is important to note that all but two scores did improve. The two scores that did not improve had no change. In fact, the data signifies marked differences between the pretest and posttest. Scores improved on the average of 19 points. Hence, while the outcome was not met, an implication can be made that using constructivist pedagogy resulted in improvements. Despite these findings, caution must be exercised in attributing the results to this program. The same caution that was described for outcome one can be used in this instance also. Improvement may have occurred without the program due to the class the students were enrolled in to help with their basic skills.

The third outcome that called for classroom grades, in mathematics, of students who did not meet standards on the mathematics subtest to be at or above the 85% mark was not met. The results showed that 52% of the students were below the 85% mark. However, it is important to note that only seven of the grades were below the 70% passing mark for the class. This indicates that the majority of the students passed the class. When questioned about the grades, the classroom teacher reported that students tended to view the class as unnecessary to graduation, therefore students did not care about the grade they received. While the class was mandatory for students who performed below standard in mathematics on the state exit exam, the class counted as an elective towards the students high school credits.

The fourth outcome was met. The fourth outcome called for an improvement in student motivation. During the implementation period, teacher observation revealed that high school students became more actively participatory in the constructivist-learning program thereby enhancing their motivation and ultimately performing better on basic skills concepts in mathematics. The review of literature indicated that students who are actively engaged in their own learning have an opportunity to express their thoughts, opinions, and ideas in such a way that the material is made more interesting to them. When the material is made more interesting, academic skills are increased. Students reported that they liked working with their peers and learning was made easier by using the methods in this applied dissertation program. However, the program did not significantly alter their attitudes about mathematics. An implication of this finding is that teachers may need to explore alternative methods of instruction to enhance student motivation and maximize student participation in the classroom. Perhaps if students use these methods at an earlier stage of their academic careers, attitudinal changes could

occur whereby students begin to enjoy mathematics. When questioned about the use of computer-assisted instruction, students replied that they did not like going to the CCC lab. One student wrote the comment that the questions were too difficult and took too much time to complete. It is important to remember that technology is a tool and it should not drive the curriculum. Therefore teachers should question if using the technology would add a higher value to the curriculum. In this case, use of the CCC lab was unpopular with the students. In addition, when reviewing reports from the CCC lab, it was noted that most students did not complete more than three units during the implementation period. Whether this is due to the time it took to complete the questions, as one student suggested, or the students dislike of the CCC lab resulting in less effort on the students part is unclear.

It has shown that using constructivist pedagogy to improve high school mathematics instruction may increase basic skills scores on the state mandated exit exam. While some outcomes were not directly met, the writer considers the applied dissertation program to have achieved success in that scores were improved and students became more motivated using the program.

### *Recommendations*

Based upon the findings of this applied dissertation program, the following recommendations and suggestions are considered important for any future use of constructivist pedagogy to help increase basic skills in mathematics.

First, it is recommended that further research be completed using a student group not enrolled in a class set-up specifically for remediation of basic skills. This would enable the researcher to clearly contribute the results to the program and eliminate the question of whether it was the program or the classroom material that increased the

scores.

Second, it is recommended that teacher in-service be provided on constructivist methods to enable the teachers to understand the importance of these methods and to correctly implement the use of them. If accountability is going to continue to be mentioned in the same breath as teacher retention, then it is time to begin staff development that ensures quality and effective learning opportunities (Hirsh & Sparks, 1999). Furthermore, a number of programs of learning standards based on constructivist principles in various subject matter areas have been launched at the national level. In addition, new classroom materials suggest approaches to teaching to these standards (Richardson, 2003). However, caution is given against blindly accepting the practice without taking into consideration that students learn in many different ways. Instead, it is suggested that teachers learn how to effectively implement constructivist principles and selectively use them where they would best benefit the student.

Third, it is recommended that the class students are required to take, if they scored below standard on their first or second attempt on the mathematics subtest on the state mandated exit exam, be changed from a required elective to a suggested elective. While the importance of the class is understood in that it provides students the remediation of mathematical basic skills and it provides evidence that the school has implemented a procedure to lower the number of students not meeting standard on the state mandated exit exam, some students who are required to take the class do so with the proverbial chip on their shoulder. By forcing them to attend the class, the school is promoting their lack of motivation. Instead, it is suggested that the class be a recommendation for the student, thereby giving them the opportunity to be responsible for their learning. In addition, if the student chooses to enroll in the class, then they may approach the class work with more

motivation and a better attitude.

Fourth, it is recommended that additional training be provided on technology use so that teachers can best provide programs that are tailored to the individual students needs. As it stands now, the CCC lab is used by the teachers voluntarily. By using educational technology students and teachers can benefit from on going assessment where students attitudes are more positive. The literature suggests that using educational technology motivates the student and in turn enhances their self-esteem. They become independent learners and develop better critical thinking skills. This is due, in part, to the constructivist approach that technology use invites. Time management becomes less of a problem when educators use technology as a teaching tool because it allows them to provide individualized attention to the students. If educators are to implement technology into their learning environment, then they need to learn to use it as part of their teaching tools. The traditional classroom should be replaced with a collaborative classroom where students and teachers are interfacing with each other in active learning. Educators can benefit from the technological know-how of the students by stepping back and allowing them to be in control of their own learning. The lecture method can be replaced by facilitation between the student and teacher. The vicissitude of technology requires constant adjustments in how it is used. When used correctly, technology is beneficial to students and educators (Kosakowski, 1998). Use of technology, in this program, enables the students to control how much they learned. However, the student needs earlier exposure to the CCC lab and the use of it in constructivist pedagogy in order to reap the full benefits.

#### *Dissemination*

The writer plans to disseminate the results of the applied dissertation program in

three ways. First, the completed manuscript will be provided to the classroom teacher, the Principal, and the Superintendent. Second, with Principal's approval, results will be shared with other mathematics teachers at an in-service. Third, writer will submit findings for presentation at the regional conference of the National Council of Teachers of Mathematics.

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Appendix  
Student Survey

Appendix  
Student Survey

**Do not put your name on this survey.** Following are a number of statements. Read each statement and rank the choices from 1 to 5, where 1 is you strongly agree and 5 is you disagree.

	Strongly Agree			Disagree	
1) At the beginning of this program, I liked math.	1	2	3	4	5
2) I liked working with my peers.	1	2	3	4	5
3) I liked working in cooperative groups.	1	2	3	4	5
4) I liked working in the CCC lab.	1	2	3	4	5
5) Working with my peers and in a cooperative group made learning easier.	1	2	3	4	5
6) Using the CCC lab made learning easier.	1	2	3	4	5
7) I felt better about learning using the strategies in this program.	1	2	3	4	5
8) I would like to use these types of activities in other classes.	1	2	3	4	5
9) My feedback was important to the teacher.	1	2	3	4	5
10) At the end of the program, I liked math.	1	2	3	4	5

Additional Comments:

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