Struggling learners of mathematics: An investigation of their learning through reform-based instruction

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UMI
STRUGGLING LEARNERS OF MATHEMATICS: AN INVESTIGATION OF THEIR LEARNING THROUGH REFORM-BASED INSTRUCTION

A Dissertation
Submitted
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education
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Jennifer Pothast
University of Northern Iowa
December, 2010
This dissertation is dedicated
to my daughters,

Megan Neuendorf

and

Morgan Neuendorf

May you always set your goals high

and work hard to achieve them.
ACKNOWLEDGEMENTS

This dissertation is the result of those family and friends who have encouraged me to continue to pursue my goals in education. Their support throughout the process has been incredible. I thank my dissertation committee members, Dr. Donna Schumacher Douglas, Dr. Jean Schneider, Dr. Robert Boody, Dr. Diane Thiessen, and Dr. Lynn Nielsen. Your time and expertise have been invaluable. I want to specifically thank Dr. Schumacher Douglas for her time and patience throughout the writing process. The commitment she has shown is sincerely appreciated.

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I also want to thank my parents. They have been role models in perseverance and patience. Mom always encouraged me to pursue an education. Although you are not here to see the final product, I know you are looking down with that smile on your face. My Dad has always believed in me and gives his words of encouragement when I least expect them, but need them the most.
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December, 2010
The purpose of this study was to explore mathematics instruction which implements reform-based problems within a traditionally taught classroom and its effect on struggling learners of mathematics. The reform-based problems implemented during the course of this study dealt with area and perimeter concepts at the fifth grade level. For this study, struggling learners of mathematics were defined as students scoring below the 40th percentile on the mathematics subtests of the Iowa Test of Basic Skills. The regular classroom teacher taught all lessons during the unit of instruction, while the researcher collected data from students using multiple methods: pretests and posttests, task-based interviews, standardized test scores, classroom observations, and pre and post attitude surveys.

Through the pretest and posttests given during the course of this study, the researcher found evidence which connects reading comprehension to mathematical understanding. Students identified as struggling learners of mathematics were more likely to accurately calculate area and perimeter when the dimensions were given as numerals rather than words. Results from this research study show an increase in the struggling learners' understanding of area and perimeter concepts when applied to problem-solving situations. The researcher conducted 10 observations of the fifth grade mathematics classroom. Through these observations, the researcher found the regular classroom teacher conducted mathematics instruction in a similar structure whether using the reform-based problems or a traditional lesson. The classroom teacher was deliberate in organizing each day's instructional time beginning with a review of basic mathematics
skills, whole-class discussion of problems and tasks, and individual work or small group exploration. The structure of instructional time, aligned with clear and consistent student expectations gave struggling learners of mathematics opportunities to be successful in learning the concepts of area and perimeter.
CHAPTER 1

INTRODUCTION

Being mathematically literate has become more important in order to be a productive member of society and the workforce (National Research Council [NRC], 2001). Fulfilled and productive citizens have moved past the traditional algorithms taught in the math classrooms of yesterday (National Council of Teachers of Mathematics [NCTM], 2000). Along with the demanding content of mathematics, the problem-solving process necessary to make decisions in today’s society places demands on schools’ curriculum and teachers’ teaching strategies which may be very different from what is currently being practiced in the math classroom (NRC, 2001). The need to understand and be able to use mathematics daily and routinely in the workplace is essential (NRC, 2001). Understanding and being competent in mathematics significantly enhance the opportunities and options for students’ futures (NCTM, 2000).

Discussions addressing the poor performance of the United States’ adolescents in the area of mathematics (Brown, 2001) have been brought to the forefront of educational reform because eighth grade students in the United States were scoring poorly on the International Mathematics and Science Assessments (US Department of Education, n.d.b., Trends in International Mathematics and Science Study [TIMSS], 2007). Besides scoring below eighth graders from other countries, the math scores of eighth graders in the United States show lower performance than would be predicted based on the scores and relative ranking of fourth graders in the United States (US Department of Education, n.d.b., TIMSS, 2007).
The research evidence is consistent and compelling in relation to weaknesses in the mathematical performance of U.S. students. State, national, and international assessments conducted over the past 30 years indicate that, although U.S. students may not fare badly when asked to perform straightforward computational procedures, they tend to have a limited understanding of basic mathematics. They are also notably deficient in their ability to apply mathematical skills to solve even simple problems (NRC, 2001).

Koehler and Grouws (1992) contended that, with the need to enhance mathematics curriculum at the middle level, teachers should not separate the symbolization of mathematics from the context. According to NCTM (2000), what is being taught in the math classroom must be relevant to society and workplace. Silver (2000) insists that the quality of mathematics learning be not only challenging, but that mathematics education must also meet the needs of young adolescents as individuals. NCTM (2000) asserted that the goals of the mathematics classroom must move past the basic goal of manipulating numbers through computation to creating future citizens who can reason mathematically. In 1986, Fong, Krantz, and Nisbett encouraged teachers to choose classroom activities that integrated everyday applications of mathematics into lessons in order to improve students' interest and performance in mathematics. Choosing classroom activities and devoting instructional time to helping students develop reasoning skills, learn problem-solving strategies, and see mathematical links to other disciplines is supported by NCTM (Krulik, Rudnick, & Milou, 2003). Lemke and Reys (1994) found that students often can give real world applications of mathematical concepts, but few were able to explain why
the concepts were actually used in that application. With a strong emphasis in math education on problem-solving and deep conceptual understanding (Gersten & Baker, 1998; Maccini & Gagnon, 2002; Woodward & Montague, 2002), true understanding of mathematical concepts is not adequate. NCTM (2000) asserted that teachers, schools, and parents should have high expectations for student achievement in mathematics which takes renewed effort and commitment from everyone, and NRC (2001) stated that schools need to prepare all students to solve problem situations that require a high level of reasoning skills, no matter what the level of math skill required. Overall, the NCTM (2000) emphasizes that math classrooms must be environments that enable students to value mathematics, become confident problem solvers and mathematicians, while learning to communicate their thinking and reasoning.

Often, only students of high ability levels have the opportunities to participate in a classroom with a problem-solving atmosphere (Montague & Jitendra, 2006). However, as an NCTM publication pointed out: “Excellence in mathematics requires equity... high expectations and strong support for all students” (2000, p. 11). This vision of mathematics education, which sees students of all abilities being successful in the math classroom, challenges a traditional social norm that only some students are capable of learning mathematics (NRC, 2001). Keeping learning expectations high for all students when mathematical expectations of the workforce are low is a difficult task for math educators (Hudson & Miller, 2006; NCTM, 2000; NRC, 2001). The NCTM argued, “All students, regardless of their personal characteristics, backgrounds, or physical challenges, must have opportunities to study and support to learn mathematics” (2000, p. 12).
Teachers must provide support for student learning by planning appropriate experiences and being responsive to students' prior knowledge, personal strengths, and intellectual strengths (Cathcart, Pothier, Vance, & Bezuk, 2000; Trafton, Reys, & Wasman, 2001).

**Conceptual Framework**

Geometry is a way to interpret and reflect on our physical environment and can be a tool for studying other areas of mathematics and science (NRC, 2001). The majority of current curricular and teaching practices in this area, however, do little to promote learning and conceptual growth (Clements, 2003; Joram & Oleson, 2004). They leave students unprepared for the future study of geometry and measurement along with other mathematical subjects that depend on geometrical knowledge (NRC, 2001).

Previous research provides support for the implementation of reform mathematics based on the NCTM Standards (Boaler, 2002; Fennema, Sowder, & Carpenter, 1999; Maccini & Gagnon, 2002). The National Council of Teachers of Mathematics has been in the forefront of encouraging the use of reform curriculum and the necessary changes in instructional techniques used in the classroom (Hudson, Miller, & Butler, 2006).

Support for the use of reform mathematics among special education classrooms and instruction with students who struggle to learn mathematics is not as common (Hudson & Miller, 2006). These students often receive much of their mathematics instruction as algorithmic instruction because the mastery of algorithms is what they are seen to struggle with the most (Allsopp, Lovin, Green, & Savage-Davis, 2003). There is a growing area of literature that advocates the teaching of mathematics for struggling learners in authentic and meaningful contexts, directly modeling problem-solving
strategies, sequencing instruction from concrete to representational to abstract, and giving students opportunities to communicate their mathematical understanding (e.g., Allsopp et al., 2003). The National Research Council states in Sheffield and Cruikshank (2005) "There are times, usually after people have grappled with issues on their own, that 'teaching by telling' can work extremely well" (p. 25).

Developing a learning environment that facilitates learning for all ability levels of students requires curriculum that engages the learner (NCTM, 2000). Students who struggle in learning mathematics are often identified with their math-related disability (Allsopp et al., 2003). There are many situations in which students who struggle in learning mathematics are not identified and therefore receive no additional help in the classroom (Allsopp et al., 2003). A main premise of mathematics reform is the importance of empowering all students mathematically to ensure they are successful when engaging in significant mathematical problems (NCTM, 2000). Math education requires regular classroom teachers to design lessons with specific mathematical learning goals that are obtainable by all ability levels. This should include those students who have been identified as needing special assistance, as well as students who have not been identified in this way (NRC, 2001).

The math reform advocated by the National Council of Teachers of Mathematics encourages teachers to create a learning environment that fosters the development of each student's mathematical power and to engage in ongoing analysis of teaching and learning (NCTM, 2000). In this context, research in the area of mathematics has become increasingly more important with a need to evaluate the effectiveness of problem-based
curricula and to monitor the impact of the changes in teaching practices and classroom curriculum that have been required by national and state governments (Woodward & Brown, 2006). Moreover, there is a need for research to investigate the role of student-related factors on learning outcomes (Montague & Jitendra, 2006).

Some students may need extra assistance to meet the high expectations of mathematics performance that has been set for them (Sherman, Richardson, & Yard, 2009). Students who are not native speakers of English may need special attention to participate in classroom discussions or assessments (Hudson & Miller, 2006). Students with disability may require extra time to complete assignments or require a written assessment to be read orally to them (Sherman et al., 2009). Students with difficulties learning mathematics may need additional tutoring or after-school programs to become competent in understanding essential mathematical concepts (Sherman et al., 2009). Students with exceptional understanding of mathematics may need additional enrichment programs or alternate resources to challenge them (NCTM, 2000). Schools must attempt to accommodate the special needs of some students without inhibiting the learning of others (NCTM, 2000).

The areas of geometry and measurement are particular areas of mathematics in which students often lack a solid conceptual understanding (Clements, 2003; Mulligan, Prescott, Mitchekmore, & Outhred, 2005). Several studies have shown that U.S. elementary and middle grade students do not have an adequate understanding of basic geometric concepts, or geometric reasoning and problem-solving (Chappell & Thompson 1999; Clements 2003; Lindquist & Clements, 2001). Without basic geometric
understandings, many students are unprepared to study more sophisticated geometric concepts in high school (Clements & Battista, 1992). Among the necessary geometric and measurement concepts of study are perimeter and area (Chappell & Thompson, 1999), real-world concepts that students need to make sense of through exploration (May, 1999; Wiest, 2005). The concepts of area and perimeter are connected to other areas of mathematics such as scaling and similarity, concepts that are developed in higher levels of geometry (Fox, 2000; Lindquist & Clements, 2001).

The lack of conceptual understanding of area and perimeter among elementary and middle school students makes these ideas confusing to many students (Chappell & Thompson, 1999; Muir, 2006). There is research evidence that students commonly confuse area and perimeter and that many elementary and secondary students lack an adequate understanding of area and area measurement (Outhred & Mitchelmore, 2000; Zacharos, 2006). Student confusion has been attributed to the use of formulas in teaching these concepts and to the consequent lack of development of a conceptual understanding of the concepts (Mulligan et al., 2005; Martin & Strutchens, 2000; Van de Walle, 2007). The ability to connect conceptually the understanding of perimeter and area to the necessary critical thinking processes is essential if students are to make sense of these two mathematical concepts (Moyer, 2001).

Significance of the Study

Teaching mathematics using a problem-centered approach uses interesting and well-selected problems to engage students and inspire exploration of important mathematical ideas (Maccini & Hughes, 2000; Trafton et al., 2001). The study of
perimeter and area measurement is a difficult topic that is taught in K-6 mathematics curriculum (Joram & Oleson, 2004). These concepts should not be a source of confusion for students. Utilizing problems in the classroom that enable students to understand the importance of perimeter and area builds conceptual understanding and connections among other mathematical concepts and principles (Hopkins, 1996).

Need for Change in Geometry and Measurement Instruction

Too often, geometry and measurement are viewed by teachers and students as the study of vocabulary (Lindquist & Clements, 2001; Outhred & Mitchelmore, 2000). This type of thinking can result in elementary and middle school classroom environments where the language of geometry has been the focus of the geometry curriculum (Lindquist & Clements, 2001). The purpose of the study of geometry at all levels needs to be clearly understood, not studied because the teacher has asked for geometric tasks to be performed (Cawley, Hayes, & Foley, 2009; Clements, 2003). The National Council of Teachers of Mathematics’ geometry standard stated that students should use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM, 2000). The study of geometry should also be used to analyze mathematical situations, thus helping students learn more about other mathematical topics. An understanding of the concepts of measurement helps students to connect ideas within other areas of mathematics and between mathematics and other disciplines (Fox, 2000; NCTM, 2000).

The vocabulary of geometry and measurement should grow naturally from the study and exploration of problems involving these concepts (Cawley et al., 2009; Lindquist & Clements, 2001). Vocabulary can limit students’ understanding unless it is
used correctly in a wide range of examples to build rich understandings of the concepts (Lindquist & Clements, 2001).

Investigating, making conjectures, and developing logical arguments to justify conclusions are important aspects of studying geometry and measurement (NCTM, 2000). All aspects of these topics must be explored. Omitting expectations about spatial orientation and location deprives students of a foundation for understanding everyday applications, such as giving and receiving directions and reading maps, and other mathematical topics, including visualizing two-dimensional and three-dimensional objects, using geometric models for numerical and algebraic relationships, working with coordinates and graphing, and perimeter and area (Clements, 2003).

The study of geometry in third through fifth grades should involve thinking and doing (Martin & Strutchens, 2000; Van de Walle, 2007). All students at this age need opportunities to sort, build, draw, model, measure, and construct their own ideas about geometric properties and relationships (van Hiele, 1999). As they are learning to reason, they are also learning to make, test, and justify conjectures about relationships (Lindquist & Clements, 2001).

Teacher's Role in Geometry and Measurement Instruction

The teacher's role in the classroom when teaching geometric and measurement concepts is essential to the successful learning of the concepts (Lindquist & Clements, 2001; Xin, 2008). The process standards developed by NCTM are a key to making the concepts understandable and attainable to all students (Rigelman, 2007). The process standards include problem-solving, reasoning and proof, communication, connections,
and representations (NCTM, 2000): (a) Problem-solving enables students to build mathematical knowledge. Students should be encouraged to use a variety of strategies to solve problems.; (b) The reasoning and proof process standard fosters students’ ability to make and investigate mathematical conjectures, develop mathematical arguments, and select various types of reasoning and methods of generating proof.; (c) Communication is an essential part of mathematical learning.; (d) Students need opportunities to share their thinking with peers, teachers, and others and be able to evaluate and analyze the mathematical strategies of others.; (e) Recognizing and using connections among mathematical ideas and understanding the math in other content areas is also an essential process standard.; (f) Students also need opportunities to create appropriate mathematical representations to model and interpret problems in math class and the world around them.

Focusing instruction using the process standards allows the teacher to provide learning opportunities for students to use geometry and foster reasoning skills through geometry and measurement (Battista, Clements, Arnoff, Battista, & Van Auken, 1998; Lindquist & Clements, 2001). It is important for these opportunities to build on students’ strengths and to allow the student to grow in their understanding of mathematics (Hudson et al., 2006; Lindquist & Clements, 2001). The teacher must establish the expectation that the class as a mathematical community is continually developing, testing, and applying conjectures about the mathematical relationships that are being studied (Hudson et al., 2006; NCTM, 2000).

Teaching and curricular practices often do not align with the recommendations of NCTM (Koehler & Grouws, 1992). Current practices promote little learning and
conceptual growth and leave students unprepared for future study of geometry, measurement, and many additional mathematical topics that require geometric knowledge (Clements, 2003; Mulligan et al., 2005). Studying geometry and measurement offers students ways to interpret and make sense of their physical environment (Van de Walle, 2007). According to Clements (2003) and others, studying geometry and measurement can be used as a tool for learning about other topics in mathematics and science, such as similarity and congruence (Fox, 2000; Lindquist & Clements, 2001). Often, these topics receive little attention (Clements, 2003).

Lack of Understanding of Perimeter and Area

Research indicates that students find it difficult to explain and illustrate perimeter and area, because the topics are learned only as sets of procedures (Van de Walle, 2007). The results of National Assessment of Educational Progress (NAEP; 2007) tests showed U.S. students scoring poorly on problems dealing with area and perimeter (Battista, 1999). Nineteen percent of fourth-grade students were able to give the area of a carpet 9 feet long and 6 feet wide (Kenney & Kouba, 1997). When presented with a similar question, 65% of eighth grade students were able to compute the correct answer (Battista, 1999).

Results of the 2007 TIMSS assessment showed 32% of eighth graders correctly answered questions on the geometry domain. This percentage is well below Asian countries such as China, Korea, and Singapore. In these countries, students correctly answered 69% to 75% of the geometry domain questions. United States fourth graders
outperformed United States eighth graders, but still performed below students in Asian countries and England.

Poor student performance often occurs because of confusion about the area and perimeter formulas (Battista, 1999; Mulligan et al., 2005). This confusion is largely due to simply telling students the formulas for area and perimeter during classroom instruction, rather than using activities that build conceptual understanding (Battista, 1999; Van de Walle, 2007).

Of the students who do use the perimeter and area formulas correctly, many do not accurately conceptualize the meaning of height and base in both two-dimensional and three-dimensional geometric figures (Clements & Battista, 1992; Grobecker & De Lisi, 2000). Students confuse the height of a shape when it is slanted and do not realize that any side or flat surface of a figure can be identified as the base of the figure (Van de Walle, 2007). It is necessary for the students to realize the height meets the base perpendicularly (Van de Walle, 2007). Students studying area measurement in particular also often become confused when a teacher tries to establish the understanding that area requires identical units in restructuring of the plane (Clements, 2003; Martin & Strutchens, 2000). This is very similar to the idea of restructuring a length into a succession of distances (Clements, 2003; Yeo, 2008). Formulas for calculating perimeter and area are often presented to students using common-shaped polygons, such as squares and rectangles (Van de Walle, 2007). When middle school students are presented with these figures simultaneously, they become confused and have difficulty explaining or illustrating perimeter and area ideas (Chappell & Thompson, 1999). Moyer (2001) stated
They disguise their lack of understanding by memorizing formulas and plugging in numbers, knowing that they need to use the numbers on the sides of the figures in some way in a formula to obtain the correct answer. Students are often unable to distinguish between perimeter and area formulas because they have not clearly discerned what attribute each formula measures. (p. 52)

**Need for Effective Instruction for Struggling Math Students**

The development of mathematics programs that are effective for all students in the classroom is one of the greatest challenges educators face (Cawley et al., 2009; Montague & Jitendra, 2006). The student population continues to become more diverse, only increasing the importance of developing and utilizing math curricula and teaching practices that will reach a wide variety of ability levels and learning styles (NRC, 2001).

Positive outcomes of reform-based mathematics instruction when used with fidelity and over long-term periods of classroom instruction have been verified by Lubienski (2006) in “Examining Instruction, Achievement, and Equity with NAEP Mathematics Data.” Research also supports explicit mathematics teaching methods for adolescents with low-ability levels or diverse learning needs (Xin, Jitendra & Deatline-Buchman, 2005). It is important to examine reform-based mathematics curricula to determine if this type of instruction can be effective for all students, including low-ability learners in the mathematics classroom (Xin et al., 2005).

As educational policies continue to require all students to be integrated into the regular math class, it is more important than ever to reach the struggling math student (Hudson et al., 2006; Miller & Hudson, 2006). For those adolescents already identified as being at-risk and achieving below expected standards in mathematics, effective instruction is a large area of concern at the national, state, and local levels (Montague &
Jitendra, 2006). The National Council of Teachers of Mathematics encouraged an integrated approach to instruction using both procedural and conceptual knowledge for all students (NCTM, 2000). Students with special needs in the math class often receive a large part of their instruction based on algorithms, a procedural type of knowledge (Kroesbergen & Van Luit, 2003; Montague & Jitendra, 2006). Many of these students still cannot perform the required algorithms accurately or efficiently (Montague & Jitendra, 2006). Allsopp et al. (2003) argued that unless there is a balance between the development of conceptual understanding and learning algorithms (procedural knowledge), students will never understand important mathematical concepts.

Teachers of upper elementary and middle school level mathematics have the added challenge of having to ensure that students have acquired the necessary foundation for higher-level studies of mathematics (Allsopp et al., 2003). A large number of students enter high school without the necessary understanding of many mathematical concepts and lack mastery of basic skills and problem-solving strategies (Cawley et al., 2009; Montague & Jitendra, 2006).

Approximately 5% to 8% of school-age students have memory or other cognitive deficits that interfere with their ability to acquire, master, and apply mathematical concepts and skills (Geary, 2004). Characteristics these students may have serve as barriers to learning mathematical concepts and skills: attention problems; faulty memory retrieval; and metacognition deficits such as the ability to apply appropriate learning strategies, the ability to evaluate their effectiveness, and the ability to change strategies when the ones in use are not successful (Allsopp et al., 2003). Students with these deficits
may feel confused about the meaning of the problems, the paths to follow in solving the problems, and the reasonableness of solutions (Cawley et al., 2009; Sherman et al., 2009). When students feel incompetent and incapable of understanding a problem, they may focus on just finding a solution to that specific situation, without understanding the underlying concept that can be applied to similar problem situations in the future (Kidman & Cooper, 1997; Sherman et al., 2009).

Desire to Change Curriculum and Teaching Practices

Curricular content and teacher practices are two factors that need to be changed to achieve higher levels of success for struggling math learners (Woodward, 2006; Yeo, 2008). “One of the main premises of the most current reform efforts in mathematics education is that educators want to empower students mathematically to ensure that they are confident and successful in exploring and engaging in significant mathematical problems” (Allsopp et al., 2003, p. 313). Students of all ability levels need to be empowered mathematically (Xin et al., 2005). Without this premise, mathematics becomes something many students try to memorize, making it difficult for students with special needs to be successful as mathematical problem solvers (Xin et al., 2005; Yeo, 2008). Understanding which curricula and teaching methods will be effective for these students puts classroom educators in a much better position to help all students appreciate the usefulness of mathematics (Allsopp et al., 2003; Hudson et al., 2006).

Purpose of the Study

This study explored the affect of instruction using reform-based mathematics problem-solving integrated into a traditionally taught mathematics classroom. The unit
addressed the mathematical concepts of area and perimeter for students at the fifth grade level. Specifically, this study focused on the impact of this instruction on fifth grade students who struggle to learn mathematics, defined for this study as students scoring below the 40th percentile on the mathematics subtests of the Iowa Test of Basic Skills. This study sought to develop a better understanding of problem-based curriculum integrated with direct instruction in the elementary classroom that is effective for all students. Problem-solving in a reform-based math curriculum is characterized as a process that should permeate the entire mathematics program and curriculum, providing the context in which concepts and skills can be learned. Problem-solving situations should evolve from real life situations in which students are able to develop and apply their own strategies to solve the problems (NCTM, 1989). Traditional math curriculum as discussed in this study pertains to the instruction of mathematics focused on algorithmic procedures and skills (Hiebert et al., 1997).

During this study, the classroom teacher taught the area and perimeter unit, while the researcher collected data from students using multiple methods: pre and posttests, task-based interviews, surveys, and standardized test scores. The researcher is presenting a descriptive case study, using both qualitative and quantitative data sources, in the completed dissertation. This study will seek to answer the following research questions:

**Research Questions**

1. What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner's understanding of area and perimeter?
2. What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner's self-perception as a mathematical problem-solver?

3. What impact does the teacher's classroom structure when utilizing reform-based problems, have on struggling learners' understanding of perimeter and area?

**Definition of Terms**

In order to have a common understanding of the concepts presented in this study, the following terms are defined for the reader:

*Algorithm:* An algorithm is a learned sequence of steps to use in solving a math problem. Students often implement an algorithm without understanding why or what they are doing (Stein, Smith, Henningsen, & Silver, 2000).

*Anchored Instruction:* Anchored instruction is an instructional technique giving students opportunities to practice relevant, authentic problem-solving situations using video-based problems called anchors (Bottge & Hasselbring, 1993).

*CRA- Concrete-Representational-Abstract:* CRA is a problem-solving technique used with low ability math students. Students use multiple representations of math concepts using manipulatives and pictures. They make connections between the visual representations and the abstract algorithm (Hudson & Miller, 2006).

*Constructivism:* Constructivism is a type of learning that allows the student to explore and construct the learning experience. The learning that takes place is active (Van de Walle, 2007).
Content Standards: The content standards established by NCTM give a description of what mathematics instruction should enable students to know and do. They specify the understanding, knowledge, and skills that students should acquire from prekindergarten through Grade 12. They explicitly describe the mathematical content that students should learn (NCTM, 2000).

Direct Instruction: Direct instruction is a teacher-centered instructional approach that is most effective for teaching basic or isolated skills. It is instruction similar to explicit instruction (Jitendra & Hoff, 1996).

Effect Size: Calculating the effect size allows research data to be compared from experiment to experiment by standardizing the differences between means. This calculation is made by subtracting the control group mean from the experimental group mean and dividing by the standard deviation of the control group. Effect size values of .30 indicates a moderately large difference, .50 indicates a large difference, and .75 indicates a very large difference (Pyrczak, 2003).

Explicit Instruction: Explicit instruction is a teacher-centered instructional approach that is most effective for teaching basic or isolated skills. This type of instruction involves continuous teacher modeling and usually used with small groups of students (Darch, Carnine, & Gersten, 1984).

National Assessment of Educational Progress (NAEP): The NAEP is a standardized test with items matched to the United States curriculum. The sampling design ensures that representative samples of students are tested (Kilpatrick, 2003).
National Council of Teachers of Mathematics (NCTM): The NCTM is an international professional organization of mathematics educators committed to excellence in mathematics teaching and learning for all students (NCTM, 2000).

National Standard Score (NSS): The standard score is a number that describes a student's location on the achievement continuum of the Iowa Test of Basic Skills. The scale used was established by assigning a score of 200 to the median performance of students in the spring of Grade 4 and 250 to the median performance of students in the spring of Grade 8. (www.education.uiowa.edu/itp/itbs_interp_score.aspx).

Paired Sample t-test: A paired sample t-test (also called a dependent t-test) compares the means of two scores from related samples (Cronk, 2004).

Performance-Based Assessment: Performance-based assessments involve the performance of tasks that are valued in the context of the curriculum and involve several procedures to solve (Linn, Baker & Dunbar, 1991).

Pierre van Heile Levels of Understanding: The van Heile levels are a five-level hierarchy of ways of understanding spatial ideas developed by two Dutch educators, Pierre van Hiele and Dina van Hiele-Geldof. Each of the five levels describes the thinking processes used in geometric contexts:

Level 0: Beginning stages of distinguishing between circles, triangles, and squares.

Level 1: Students recognize shapes and form mental images.

Level 2: Students recognize and characterize shapes by their properties.

Level 3: Students can form abstract definitions, determine necessary conditions
for a concept, and provide logical arguments in the mathematical area of geometry.

Level 4: Students can determine the differences among undefined theories and definitions and can construct a proof based on the givens of the situation (Clements, 2003).

*Principled Knowledge:* Principled knowledge is a term used to discuss students knowing key ideas and concepts that can be used to construct procedures for solving math problems (Lampert, 1986).

*Procedural Knowledge:* Procedural knowledge is a term used to discuss students knowing mathematical computational procedures (algorithms) that are predetermined steps to compute correct answers (Lampert, 1986).

*Process Standards:* Process standards have been established by NCTM as standards highlighting ways of acquiring and using the mathematical content knowledge described in the content standards. The process standards include reasoning and proof, communication, representation, problem-solving, and connections (NCTM, 2000).

*Reform-Based Mathematics:* The term, reform-based mathematics, is a term used to redefine what mathematical knowledge is and how math is taught in schools (Spillane & Zeuli, 1999).

*Standard Deviation:* The standard deviation is calculated by evaluating the square root of the squared deviations from the mean. When the standard deviation is large, the deviation from the mean is large (Pyrczak, 2003).
Standards-Based Mathematics: Standards based mathematics instruction is an approach to teaching and learning math that involves more cooperative learning, more emphasis on concepts and problem-solving, and incorporation of a variety of forms of technology (Bryant, Kim, Hartman, & Bryant, 2006).

Trends in International Mathematics and Science Study (TIMSS): The TIMSS study is conducted by the National Center for Educational Statistics (NCES) as part of the United States Department of Education Institute of Educational Sciences comparing student achievement in math and science internationally (U.S. Department of Education, n.d.a.).

Traditional Math Curriculum: Traditional math curriculum is based on mathematics textbooks that lack problem-solving applications and consist mainly of practice problems developing basic math facts and rely on mathematical algorithms (Reys & Bay-Williams, 2003).
CHAPTER 2

REVIEW OF LITERATURE

As educators decide what mathematics programs they want for their students, they should be aware of how students learn (Hudson et al., 2006; Moon & Schulman, 1995). Choosing classroom activities and devoting instructional time to helping students develop reasoning skills, learn problem-solving strategies, and see mathematical links to other disciplines is supported by the National Council of Teachers of Mathematics (Krulik et al., 2003). Student learning styles should direct the curriculum that is put in place in the classroom along with the instructional methods used to deliver the curriculum (Moon & Schulman, 1995). Instruction in the classroom needs to support the learning style of the student to build true conceptual understanding of mathematics (Van de Walle, 2007). The Mathematical Learning Committee of the National Research Council (2001) stated

School mathematics in the United States does not now enable most students to develop the strands of mathematical proficiency in a sound fashion. Proficiency for all demands fundamental changes are made concurrently in curriculum, instructional materials, classroom practice, teacher preparation, and professional development. These changes will require continuing, coordinated action on the part of policy makers, teacher educators, teachers and parents. Although some readers may feel that substantial advances are already being made in reforming mathematics teaching and learning, we find progress toward mathematical proficiency to be woefully inadequate. (p. 409)

In 1989 the National Council of Teachers of Mathematics (NCTM) articulated mathematics standards "proposing students solve real-world meaningful mathematical problems, offer conjectures, and justify their solutions and that reformers argue for dramatic changes in what America’s students should know and be able to do mathematically" (p. 6).
This literature review will use the findings of an extensive range of previous research studies to place the current study in context. It will first provide an overview of the recent math reform in the U.S. and discuss what is known about the importance of the teacher's role and the essential characteristics of effective mathematics instruction. The available research evidence regarding the effectiveness of reform-oriented problem-solving methods of math instruction compared with traditional procedural-based instruction will be discussed, in relation to students generally and more specifically in relation to low-achieving students. Finally, the available research evidence about the teaching of geometry and measurement, and specifically the concepts of area and perimeter, will be considered.

Overview of Mathematics Reform

Mathematics reform is an attempt to redefine what mathematical knowledge is and how it is different than doing math traditionally in schools (Spillane & Zeuli, 1999). Many students have perceived and experienced math as a set of rules and procedures to be followed (NCTM, 2000). Reformers attempt to establish the difference between procedural knowledge and principled knowledge (Spillane & Zeuli, 1999). Spillane and Zeuli (1999) defined procedural knowledge as knowing computational procedures and being able to follow predetermined steps to compute correct answers. Principled knowledge, on the other hand, involves understanding key ideas and concepts that can be used to construct procedures for solving mathematical problems (Lampert, 1986). Students need to be given academic tasks that help to develop their ability to engage in
mathematical thinking, to learn to develop conjectures, to solve problems, as well as to explain and to justify their solutions (NCTM, 2000).

Problem-solving as defined by the NCTM Principles and Standards is “engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings” (NCTM, 2000, p. 52). Teachers should view problem-solving in this way in order to educate students to be true mathematical thinkers (Sherman, Richardson, & Yard, 2009; Woodward & Montague, 2002). Teachers should not view students’ computational proficiency as the only proof of effective mathematical instruction, but as a tool to use in problem-solving (Sherman et al., 2009). Often, students of high ability levels have more opportunities to participate in a classroom with a problem-solving atmosphere (Montague & Jitendra, 2006). According to the NRC (2001), students of all abilities should be successful in the math classroom.

With newly established standards, math educators across the nation were propelled into an historic mathematics reform to create mathematically literate students and help the United States to regain a competitive edge internationally (Van de Walle, 2007). Any effective evaluation of progress in mathematics reform must consider classroom instruction as a key component (Van de Walle, 2007).

Essential Characteristics of Effective Mathematics Instruction

A comprehensive, balanced, and rigorous curriculum is necessary for student success in mathematics (Larson, 2002). Characteristics of a quality curriculum program as defined by the Center for Science, Mathematics, and Engineering Education (1999)
included content with established goals and standards based on state policies and national standards. Other characteristics include a common vision among math educators, use of effective instructional materials, and continuous revision and reflection.

In recent guidelines established by Iowa Core Curriculum (2009) through the Iowa Department of Education, expectations are specified in an effort to improve teaching and learning to ensure that all Iowa students engage in a rigorous and relevant curriculum. The Iowa Core Curriculum identified the main factors contributing to effective learning student-centered classrooms, curriculum that involves rigor and relevance, teaching for understanding, assessing for learning, and teaching for learner differences (2009). This document also included specific instructional goals that parallel the characteristics of a quality curriculum program developed by the Center for Science, Mathematics, and Engineering Education. Similar teaching goals specified by Iowa Core Curriculum included developing deep conceptual and procedural knowledge of mathematics; posing problem-based instructional tasks that engage students and allow teachers to provide guidance; promoting student discourse; and extending students’ thinking by challenging them to apply their knowledge in new real-world situations (2009).

There is increasing evidence that effective instruction is a key factor in helping students to understand mathematics and ensure their success in this subject (Boaler, 2002; Cohen, Raudenbush & Ball, 2000; Sanders, 1998). Classroom activities and instructional time devoted to helping students develop reasoning skills, learn problem-solving strategies, and make mathematical connections to other disciplines is key to successful
student learning (Krulik et al., 2003). Larson (2002) suggested five essential characteristics of mathematics instruction used by effective math teachers, and several ways to implement these five characteristics depending on the needs of the students, the objective being taught, available resources, and teacher preference (Larson, 2002). Whether teachers focused on student discovery or teacher-directed instruction, effective instruction occurred when all five of the following characteristics were present:

1. Introduction: The introduction includes an opening activity designed to access students' prior knowledge and share the objective of the lesson. This helps the students and the teacher to focus on what is important.

2. Development of concept or skill: The development of a concept or skill focuses on instructional activities which actively engage students during learning.

3. Guided practice: This phase of instruction involves the teacher giving students certain problems to work on alone or in groups, and then these problems are discussed together. This phase serves as a check on student understanding and, depending on discussion, might indicate a need for additional instruction.

4. Summary: The summary phase can be the most important phase of instruction. During this phase, the teacher, through careful discussion and questioning, helps students connect mathematical outcomes of the lesson to the objective of the lesson, to previously learned mathematics, and to mathematics yet to be learned.

5. Independent practice: Practice time is necessary for students to master mathematical skills. Often, this practice is in the form of written practice but can also be found in carefully designed activities that reinforce concepts and skills.
The Teacher’s Role in Mathematics Instruction

The instruction that takes place in the classroom on a day-to-day basis is a “vast, complex, and multidimensional practice” (Spillane & Zeuli, 1999). To reach a goal of developing mathematical understanding and power for all students requires the creation of curriculum and a learning environment that facilitates activities that engage the learner. According to the NCTM Principles and Standards (2000), the teacher’s role in classroom discourse includes posing questions and tasks that engage and challenge each student’s thinking, listening carefully to each student’s ideas, asking students to clarify and to justify their ideas orally and in writing (NCTM, 2000). Teachers must make thoughtful decisions as to when to provide students with information, when to model a problem, and when to let a student struggle with difficulties (NCTM).

The selection of a worthwhile mathematical task is also an essential skill of the mathematics educator in the utilization of reform mathematics (Hiebert et al., 1997). The teacher of mathematics should pose tasks that are based on significant mathematics, knowledge of students’ understandings, interests, and experiences, and knowledge of the diverse ways that students learn (Ben-Hur, 2006; Hiebert et al., 1997). The guidelines for curriculum and instruction that NCTM has established encourage teachers to create a learning environment that fosters the development of each student’s mathematical power and to engage in ongoing analysis of teaching and learning (NCTM, 2000). The role of the classroom instructor is a key element in progress towards true reform in mathematics education (Hiebert et al., 1997). It is the teacher’s role to organize and plan experiences so students will construct mathematical meaning (Hudson et al., 2006).
What are considered reform practices in the math classroom? A study reported in Education Policy Analysis Archives (Lubienski, 2006) determined that several reform-oriented factors were significantly related to student achievement: “In every case when a teacher-reported, reform-oriented instructional factor was significantly related to achievement, the relationship was positive” (Lubienski, 2000, p. 21).

According to Spillane and Zeuli (1999), the identification of current instructional practices is important in order to improve understanding of the relationship between reform mathematics and teaching. The practices of mathematics teachers in the context of recent national, state, and local efforts to reform mathematics education were evaluated by these authors. The researchers developed a framework for examining reform efforts in the math class by looking at classroom tasks in combination with discourse patterns in the case of both principled and procedural mathematical knowledge.

In the Spillane and Zeuli (1999) study, teachers from the 25 districts sampled reported teaching mathematics in ways that were in some way related to state and national standards frequently. When interrogated about how many times they asked students to explain their reasoning, more than 60% of elementary teachers reported asking students to share their problem-solving thought processes on a regular basis. Among these elementary level teachers, the incorporation of problem-solving was not being used as consistently as the requirement for student explanations of thought processes. It was also found that the teachers were not successfully using problems advocated by the mathematics reform movement. Reformers encourage classroom use of problems which have no immediate solution. It was found in this study that teachers were
often using "story" type problems but not the problem-solving curriculum intended by the reform movement (Spillane & Zeuli, 1999).

Spillane and Zeuli (1999) reported similar results in evaluating teacher practices. The practices of teachers from the 25 school districts were categorized into three categories: (a) conceptually grounded tasks and conceptually centered discourse, (b) conceptually oriented tasks and procedure bounded discourse, and (c) peripheral changes, continuity at the substantive core (Spillane & Zeuli, 1999). Only three of the 25 teachers were found to be using practices and problem-solving tasks that supported the NCTM standards. Ten of the teachers were using open-ended problem-solving situations, but class discussions were directed to mathematical procedures and processes. Eleven teachers fell into the third category, as they were not connecting the classroom activities and lessons to NCTM standards but were emphasizing procedural thinking (Spillane & Zeuli, 1999).

Spillane and Zeuli (1999) also investigated what teachers classify as reform efforts in their classroom. Over half of the teachers in their study stated that they were using reform-type teaching strategies, and it was found that they often tended to use reform rhetoric to rename traditional practices. Many of the teachers reported that they were making changes which were moving in the direction of mathematics reform. Often, these teachers were able to make behavioral adjustments to instruction more than the epistemological regularities that occur in the classroom. The authors argued that these behavioral changes are necessary but not sufficient for the transformation of education in
mathematics and highlight the many implications for teachers, policy makers, and those who support teachers in the classroom (Spillane & Zeuli, 1999).

Comparing Problem-Solving Approaches

Many students think they cannot carry out problem-solving because they are unsure how to apply their own reasoning to the questions posed (Hudson et al., 2006; Sherman et al., 2009). Yet good problem-solving opportunities give students a chance to solidify and extend what they know (Ben-Hur, 2006; NCTM, 2000; Trafton et al., 2001). The most common struggle students have with problem-solving is in achieving a clear understanding of what is being asked of them (Hudson et al., 2006; Sherman et al., 2009). The context of the problem does not make sense and/or the context is not clearly translatable to a mathematical sentence (Sherman et al., 2009). Other issues that cause students to struggle with problem-solving include insufficient understanding of mathematics vocabulary, limited ability to read problems, and limited verbal ability to explain thinking (Montague & Jitendra, 2006; Sherman et al., 2009). All of these literacy issues add to the overwhelming dilemma of how to effectively implement problem-solving curricula accessible to all students in the classroom (Sherman et al., 2009). Related factors include number sense issues and instructional issues (Sherman et al., 2009). Many students have difficulty in focusing on the important information, limited ability to picture the situations, or limited self-checking ability (Allsopp et al., 2003). These factors often result in limited personal appeal for the students and limited time to solve the problems (Allsopp et al., 2003).
In Boaler’s study (2002), which compared two similar school districts and the implementation of mathematics curriculum, different approaches to problem-solving and subsequent differences in successful learning were identified. This ethnographic study compared two middle grade schools in England and used longitudinal cohort analysis as well as qualitative case study research to contrast their different mathematical approaches (Boaler, 2002). The study found that students who experienced a more reform-based problem-solving situation were more successful at retaining and applying their learning. Students receiving procedural driven instruction at Amber Hill School experienced difficulty when tested. They were not given the necessary depth of understanding and had to rely more on memory. The performance of students at Phoenix Hill School, where a more reformed method of math instruction was used, was markedly different. The researcher found that students at Phoenix Hill did not just learn methods and processes in the math classroom; they learned to think mathematically. The results indicated that the reform-oriented teaching pedagogies used at Phoenix Hill helped shape the learners’ knowledge and defined the students as mathematicians through practices in which they engaged in the classroom (Boaler, 2002).

In Boaler’s (2002) study, teachers who implemented true mathematical reform practices that supported principled mathematical knowledge, rather than procedural knowledge, created more successful problem solvers who could apply their learning to alternate situations (Boaler, 2002). On the other hand, research has shown that teachers who use problem-solving with traditional classroom discourse are not nearly as
successful in creating thinkers who can transfer their problem-solving abilities to other tasks (Boaler, 2002; Ben-Hur, 2006).

Problem-solving in the mathematics classroom is a creative, necessary process and skill all students need to develop (Trafton et al., 2001; NRC, 2001; Van de Walle, 2007). Those who have difficulties need carefully planned, methodical, guided mathematics curriculum and teaching methods that provide opportunities for the students to reason for themselves (Hudson et al., 2006; Sherman et al., 2009). Problem-solving tools, taught in conjunction with applied problems that appeal to students’ interests, will improve students’ problem-solving skills (Bottge, Heinrichs, Mehta, & Hung, 2002; Sherman et al., 2009). Students view problem-solving in the applied problems math classroom as having a purpose and in turn learn mathematical concepts in a meaningful, lasting way (Sherman et al., 2009).

Reform Mathematics and Low Achieving Math Students

Concerns have been raised about reform-based mathematics instruction and its effectiveness with all students (Lubinski, 2006). One assumption underlying the mathematics reform movement is that this type of instruction is effective for all students, including low achievers (Hudson et al., 2006). Many mathematicians who gained extensive understanding through more traditional routes object to the reform-based mathematics instruction, along with educators that want to maintain the traditional atmosphere of the mathematics classroom (Gersten & Baker, 1998; Gersten & Chard, 2001) Some educators who focus on equity have expressed concerns that reform-
oriented approaches to mathematics may not enhance the achievement of all students as math reformers originally hoped and claimed (Lubienski, 2000).

Baxter, Woodward, and Olson (2001) studied the response of low-achieving third graders in five classrooms to reform-based mathematics instruction and concluded that the form of content of instruction must be adapted to meet the needs of the low-ability learners. If these adaptations are not met, according to Baxter et al., low achievers cannot experience the full benefit of reform-based mathematics instruction. Woodward and Baxter (1997) also researched innovative curriculum and found that it clearly benefitted average and above average students more than those students with learning disabilities and low achievers.

Reform-based instruction was found to be more effective than direct instruction for low achievers by Kroesbergen, VanLuit, and Maas (2002). The reform-based instruction supported by the NCTM has shown promising outcomes with positive effects being found for both student performance and motivation (Kroesbergen et al., 2002). Such constructivist instruction appears to motivate students. Increase in student motivation could possibly be because of the student discourse that occurs and the challenge that this type of instruction offers the learner (Kroesbergen, VanLuit, & Maas, 2004).

Kroesbergen et al. (2004) studied students working with a variety of materials to represent mathematical ideas and processes in different ways while communicating their knowledge with one another. In this experimental study, two samples of 5 students received 30 minutes of either constructivist or explicit instruction twice a week for 5
months. Pretests and posttests were given to compare problem-solving skills, problem-solving strategies, and motivation among the research participants with members of a control group that followed the regular mathematics curriculum. On the basis of the study’s findings, Kroesbergen et al. (2004) concluded that recent reforms in math instruction, which emphasize the construction by students of their own understanding of mathematical concepts, may not be effective for struggling math students.

In another study Kroesbergen and Van Luit (2003) studied the effectiveness of math interventions for special needs students. Their study discussed three types of mathematics methodology: explicit/direct instruction, cognitive self-instruction (i.e., step-by-step procedures often used in explicit/direct instruction), and assisted instruction (i.e., methods consistent with reform-based mathematics). Kroesbergen and Van Luit (2003) found the explicit/direct instructional methodology more effective for teaching math facts and problem-solving to students with learning difficulties than the other two methodologies in the study.

The seriousness of not understanding mathematics is magnified for those adolescents identified as being at risk and achieving below expected standards in mathematics (Bottge & Hasselbring, 1993; Maccini & Hughes, 2000). By the time students with learning disabilities reach secondary school, they not only lag behind their peers in basic mathematical skills, but also lack proficiency in higher order skills (Bottage & Hasselbring, 1993). Low achieving students often struggle with deliberate memory tasks which decreases self motivation in the math classroom (Reschly, 1987).
Delpit (1988) expressed concerns about reform movements in education, challenging the idea that reform mathematics can distribute achievement more equitably. She contended that schools reproduce a culture of power and that “if you are not already a participant in the culture of power, being told explicitly the rules of that culture makes acquiring power easier” (p. 281). Focusing upon reading approaches used in the classroom, this author asserted that skills-oriented approaches may be more equitable because they teach skills directly rather than providing experiences for children to learn the skills (Delpit, 1988). It has been observed that reform-oriented approaches in the classroom have not reduced inequality or improved understanding of mathematical concepts (Delpit, 1988; Lubienski, 2000). There is a need for a greater understanding of the ways in which mathematics reform teaching methods are developed and implemented in the classrooms (Kroesbergen et al., 2004).

Teaching Students Who Struggle Learning Mathematics

Effective pedagogical approaches in the classroom have benefited the struggling learner when curriculum content, context of the classroom, and academic and social behavior expectations were multidimensional and systematic (Xin et al., 2005). Research supports the belief that students who struggle with learning mathematics need explicit instruction for conceptual understanding (Gersten & Baker, 1998; Hudson et al., 2006; Kroesbergen & Van Luit, 2003). It is critical to establish the necessary knowledge before implementing problem-solving in math instruction (Xin et al., 2005). Often, these students have not succeeded in math with a one-size-fits-all type of instruction and have lacked resilience capacity to overcome personal and environmental obstacles (Bernard,
1995). Contributions from the school that increased the mathematics performance of low achieving students included caring and supportive relationships, positive and high expectations, and opportunities for meaningful participation in classroom discourse (Hudson et al., 2006; Sherman et al., 2009).

According to Miller and Hudson (2006), these students have concrete thought processes and benefit most as learners from visual and kinesthetic instruction. Tactile involvement with the environment enhances their learning, and verbal communication is preferred by them over written communication (Cass, Cates, Smith, & Jackson, 2003). Although they communicate verbally, their level of vocabulary is low in meaning (Miller & Hudson, 2006). Woodward (2006) found that, emotionally, low-achieving students are often fragile, having a low sense of self security. They may view the educational system as a threat to self preservation, making them react negatively to rigid order and direct confrontation. Although loyalty for these students is extremely strong, it takes time to develop as they are hesitant to establish relationships (Sherman et al., 2009; Woodward, 2006).

Sherman et al. (2009) found evidence of several factors that resulted in students being unsuccessful at math. The authors grouped these factors into two categories: environmental and personal-individual. Environmental factors included instruction, curriculum materials, and the gap between the learner and the subject matter, whereas personal-individual factors included locus of control, memory ability, attention span, and understanding the language of math (Sherman et al., 2009).
Instruction of mathematics must provide many opportunities for building concepts through challenging questions, problem-solving activities that emphasize reasoning, and connections within the curriculum to real world situations (NCTM, 2000). Memorization may be necessary, but students who rely too heavily on rote memorization isolated from meaning have difficulty retaining the math concepts (Krulik et al., 2003; Sherman et al., 2009). Curriculum that is organized in a spiraling format allows the learner the opportunity to deal with content developmentally over time. Research has found that the curriculum needs to be accessible to the student’s abilities (e.g., Van de Walle, 2007). When the math taught is unconnected to the student’s ability level and past experiences, evidence shows that the achievement gap widens (Hudson et al., 2006; Sherman et al., 2009).

Many personal factors have been found to contribute to the low-achieving math student’s level of performance in the classroom (Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; Sherman et al., 2009). Some students think that their math achievement level is based on luck or believe that, if they scored well the material must have been easy. Any success is attributed to factors outside of their control; they do not see this as due to understanding or hard work (Sherman et al., 2009). In Sherman et al.’s 2009 research, many of the low-achieving students lacked well-developed mental strategies for remembering how to complete algorithmic procedures and combinations of basic facts. Procedural skills taught through repetition presented in game format were successful in helping them to gain mathematical understanding (Sherman et al., 2009).
Struggling math students are easily distracted and therefore have difficulty focusing on multi-step problems and procedures (Hudson et al., 2006; Miller & Hudson, 2006; Sherman et al., 2009). Students who struggle learning math are often confused by math vocabulary terms such as volume, yard, power, and area, which hinders their understanding and ability to focus on algorithmic operations and problem solving (Clements, 2003; Sherman et al., 2009).

Students who were not successful in traditional procedural approaches to mathematics instruction also struggled with problem solving in the math classroom (Allsopp et al., 2003; Kroesbergen & Van Luit, 2003). Many of these students thought they could not do problem-solving because they were unsure of ways to apply their own reasoning to questions (Allsopp et al., 2003; Sherman et al., 2009). Yet good problem solving situations gave students the opportunity to solidify and extend what they already knew (Hudson et al., 2006; Sherman et al., 2009). This directly connects to NCTM’s definition (2000) of problem solving as “engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understanding” (p. 52).

A common struggle for students when working on a problem is how to interpret what is asked of them initially to solve the problem (Allsopp et al., 2003; Hudson et al., 2006). If the context of the problem is unfamiliar to them or does not make sense, or if the problem is not clearly translatable to a number sentence, the students easily became frustrated (Allsopp et al., 2003). Little understanding of math vocabulary and limited
ability to read problems and verbally explain one’s thinking lead to early frustration and, in turn, low achievement (Allsopp et al., 2003; Clements, 2003; Sherman et al., 2009). Other limiting factors included difficulty focusing on important information, limited ability to visualize the situation, limited self-checking ability, little interest in the context of the problem, and limited time to solve problems (Allsopp et al., 2003; Clements, 2003).

Effective Mathematics Instruction for All Students

The development of mathematics programs that are effective for all students in the classrooms is a challenge for any mathematics educator (Hudson et al., 2006; Maccini & Gagnon, 2002). Increasing numbers of students with special needs are placed in the regular math class instructed by the regular classroom teacher (US Department of Education, n.d.a.). As the needs of the diverse learners in the classroom become more numerous, the development of mathematics curriculum and instruction that meet the needs of all students is important (Hudson et al., 2006; Hudson & Miller, 2006). For the past decade, educators and researchers have advocated for reform-based mathematics instruction based primarily on the work of the NCTM (Hudson et al., 2006). National and state standards supporting reform characteristics have been established and integrated into the math instruction and curriculum (Woodward & Montague, 2002). However, many educators researching methods of instruction for adolescents of diverse learning needs continue to support explicit teaching methods for mathematics instruction (Hudson et al., 2006). With the current emphasis on access and accountability for all students in general education mathematics curriculum, Hudson et al. believed it is critical to examine
the reform-based mathematics approach and the explicit teaching approach to determine if the two approaches can work together for the benefit of all students. Woodward and Montague (2002) stated that if this is possible, the likelihood of advancing mathematics competence among diverse learners will be enhanced. Efforts to combine these two different approaches to mathematics instruction are still in the early stages but do seem possible according to Miller and Hudson (2006).

Sheffield and Cruikshank (2005) stated that “there are times, usually after people have first grappled with issues on their own, that ‘teaching by telling’ can work extremely well” (p. 25). Whereas many researchers believe that students with learning difficulties need direct and explicit instruction to learn problem-solving skills and basic facts necessary for computation (Hudson et al., 2006; Jitendra & Hoff, 1996), there is evidence to show explicit instruction also helps learners gain greater automaticity (Bottge, 2001).

Research by Jones, Wilson, and Bhojwani (1997) found that students with learning disabilities and low math achievers require explicit instruction to learn math concepts, skills and relationships. Multiple approaches and alternative strategies presented by a teacher or other students may only lead to confusion on the part of such students (Jones et al., 1997; Miller, 2002). Explicit instruction also leads to increased motivation of low achievers because it enables them to handle difficult tasks and motivates them to attempt new tasks (Ames & Ames, 1989; Harniss, Carnine, Silbert, & Dixon, 2002).
Retention of concepts learned in class and their application to real world problems is an issue in the regular classroom and even more so in the special education classroom (Montague & Jitendra, 2006). Retention and transfer of knowledge learned in school are two of the most critical problems in special education practices (Woodward & Baxter, 1997). Woodward and Baxter found that in general education math settings with curriculum based on NCTM (2000) standards, minimal levels of achievement were met by students with learning disabilities. Many researchers and educators continue to support explicit instruction when working with students with diverse learning needs (Gersten, Baker, & Marks, 1998; Mercer & Mercer, 2005).

The findings of research by Darch, Carnine, and Gersten (1984) also supported similar explicit instruction in mathematics problem-solving in a 4th grade classroom. Darch, et al. (1984) explored the impact of providing direct instruction in problem-solving with more practice time. This study contrasted explicit translation with immediate teacher correction, in a four-step strategy for translation of story problems. The research subjects were fourth graders who had failed a problem-solving test, answering fewer than half of the questions correctly. The fourth graders were taught in groups of two, three, or four by graduate students in special education who all had previous teaching experience. Prior to the study, teachers had received training using role-playing techniques that parallel direct instruction programs. The study revealed an improvement in student performance as a result of explicit instruction regardless of whether additional practice was provided. The analysis of an instructional domain to determine details and essential strategies was found to be beneficial for the students to perform at a level of proficiency.
Darch et al.'s. findings supported the idea that programs in mathematics constructed to teach prerequisite skills in a sequential manner are more effective than relying solely on problem based problems and activities.

A study by Gersten and Baker (1998) established that students with learning disabilities do often possess the knowledge to problem solve in the math class but either have little awareness of this knowledge or do not know how to apply it. The students in this study also tended to withdraw from unclear problem-solving situations that demanded higher levels of thinking. Gersten and Baker argued for a combination of classroom instruction, including direct or explicit instruction and the newer cognitively-based approaches which emphasize problem-solving. The findings of their research was promising in that structured teaching of core mathematical concepts combined with development of procedural knowledge using less-well-defined, real world problem-solving experiences were found to enhance understanding, transfer, and maintenance.

Learning disabilities in the adolescent years were the subject of a study by Bottge and Hasselbring (1993), with a specific focus on problem solving in mathematics. Two groups of adolescents with learning difficulties in mathematics were compared on their ability to solve contextualized problems after taught problem-solving skills in two ways: one form of instruction involved standard word problems, and the other centered on contextualized problems presented to students on videodisc (Bender, 2005; Bottge & Hasselbring). All of the problems the students were asked to solve focused on adding and subtracting fractions in relation to money and linear measurement (Bottge & Hasselbring). The study used anchored instruction to develop problem-solving ability in
students with learning disabilities. This technique allowed students the opportunity to practice relevant knowledge retrieval in contexts they recognize and regard as important (Bender, 2005; Bottge & Hasselbring, 1993; Bottge, Ronald, Hung, & Kwon, 2007; Woodward & Montague, 2002). It required guidance by an effective teacher in order to provide students with a rich source of information. In Bottge and Hasselbring’s study, the students were asked to create a solution to problems presented to them by determining what information was relevant from what was displayed on the screen. In this way, the problem presented to them was posed as a real world problem. As a result, their concluded that students who engaged in real-world problem-solving experiences such as those presented on the videodiscs were more successful in transferring what they learned to another set of real-world problems.

Integrating Reform Mathematics Curricula with Explicit Instruction

There are conflicting beliefs and research findings regarding the application of constructivist learning theories and the application of more explicit instruction for low achieving students (Hudson et al., 2006). Articulating mathematics is important whether you are teaching in a reform-based classroom or using teaching methods of explicit instruction (Hudson et al., 2006; Larson, 2002). The process of adapting and merging explicit teaching and reform-based mathematics instruction demands careful thought and planning (Hudson et al., 2006; Scheuermann, Deshler, & Schumaker, 2009). To increase the likelihood that the needs of all students are met, it is beneficial for the special education teacher and the general math teacher to collaborate in planning (Hudson et al., 2006).
According to Hudson et al. (2006) it is beneficial for teachers when planning instruction to identify three groups of students: high achievers, average achievers, and low achievers. Moreover, several variables should be taken into account when planning instruction for a group of students with diverse needs (Hudson et al., 2006; Larson, 2002; Woodward & Montague, 2002). Even though differences exist among students, the commonalities in student needs should serve as guiding principles when planning and developing instructional units and lessons, according to Hudson et al. (2006). The first of these commonalities is a positive response from all students to instruction in areas of high interest. To achieve this, it is helpful to use mathematics problems and situations that are age-appropriate and linked directly to students’ lives and interests (NCTM, 2000). As a number of studies have shown, instruction provided in meaningful contextual situations helps students make connections between classroom activities and real world problem solving (Fennema et al., 1999; Hiebert et al., 1997; Hudson et al., 2006). Activity-oriented problem-solving can help build conceptual understanding of mathematical concepts (Maccini & Gagnon, 2002; Woodward & Montague, 2002).

High, average, and low functioning students need an appropriate level of challenge in math curriculum, according to Hudson et al. (2006). Although challenging and time consuming for the teacher, preplanning was found to help guide the teacher in individualizing instruction for different ability levels of students (Hudson et al., 2006; Larson, 2002). In reform-based mathematics and explicit teaching, questioning and discussion are a vital part of the instructional process (Hudson et al., 2006; Larson, 2002; NCTM, 2000). Hudson et al. found that varying the type and level of questioning, as well
as the amount of support given to students at different ability levels, helped provide individualization. Adapting the guided practice, typically used in explicit teaching, to meet the needs of students with various ability levels within reform-based problem-solving contexts is possible (Hudson et al., 2006; Maccini & Gagnon, 2002).

Progressing through curriculum before concepts are mastered has been found to be problematic, especially in mathematics (Allsopp et al., 2003; Fennema et al., 1999). The hierarchical nature of this content area allows gaps in understanding to negatively affect performance in subsequent units and lessons (Hiebert et al., 1997; Klausmeier, 1992). Thus, it is important that all levels of learners of mathematics experience adequate practice to ensure mastery and generalization of the mathematics content (Hiebert et al., 1997). Supplemental problems can extend the learning of the high achievers and allow additional time for the low achievers to master critical concepts before moving on (Hudson et al., 2006). High achievers have also been shown to benefit from opportunities to serve as peer tutors for low achievers (Copes & Shager, 2003). The benefits of peer tutoring include the solidification of the tutor's own math knowledge, as well as improved self esteem among all students, and increased understanding of student diversity (Copes & Shager, 2003).

The application of explicit teaching to a problem-solving approach to mathematics which benefits the low ability student is possible when guiding principles for planning and delivering math instruction are followed (Copes & Shager, 2003). The guiding principles for planning and instruction that need to be taken into consideration include considering student interests, choosing the appropriate level of challenge, and
ensuring mastery before progressing in the curriculum (Copes & Shager, 2003). Hudson et al. (2006) have shown how the integration of the NCTM process standards with explicit teaching strategies can be possible. Programs such as anchored-based instruction and concrete-representational-abstract (CRA) instruction have strived for curriculum relevance emphasizing the importance of connections and multiple representations of concepts, skills, and knowledge, and have prepared students to be active problem solvers through reasoning, communicating, and effective practice (Hudson et al., 2006; Scheuermann et al., 2009).

Geometric and Measurement Instruction

Geometry and measurement are areas of mathematics considered essential (Cawley et al., 2009). Students at all ages and abilities need to study geometry for a purpose, rather than performing geometric tasks just because the teacher has asked them to do so (Lindquist & Clements, 2001). Geometry and measurement signify mathematics in everyday life, offer opportunities to enhance cognitive thinking skills, and improve communication processes and language comprehension (Cawley et al., 2009). The NCTM Principles and Standards (2000) stated students should use visualization, spatial reasoning, and geometric modeling to solve problems. Studying geometry that analyzed mathematical situations has been shown to help students learn more about other mathematical topics (Lindquist & Clements, 2001).

Too often, however, geometry curriculum in United States prekindergarten classrooms through eighth grade classrooms has been an informal introduction to a few basic concepts (Clements, 2003). Geometric learning begins with naming geometric
objects and does not usually provide any deeper conceptual understanding (Fox, 2000; Van de Walle, 2007). This may help to explain why fifth graders from Japan and Taiwan scored more than twice as high as U.S. students on the initial Trends in International Math and Science Study (US Dept. of Education, n.d.b., TIMSS, 2007; Stigler & Stevenson, 1990), a study establishing the basis for future, more in-depth TIMSS research. United States curriculum and instruction of geometry has been generally weak, but there seems to be some effort being made to introduce guidelines to improve instruction of geometry (Clements, 2003). Some geometric theories of thinking and learning have been influenced by Piaget and Inhelder (1967). These theorists' ideas include student representations of space constructed through progressive organization of prior experiences and manipulation of spatial environment. Other writers have argued that the organization of geometric ideas should be logical in sequence (van Hiele, 1999) and that topological relations, then projective concepts, followed by Euclidean relations, should be constructed (Clements, 2003).

Research indicates that all types of geometric reasoning develop with time and become integrated (Cawley et al., 2009; Clements, 2003). Researchers have found that students move through five progressive levels of geometric thought (Clements, 2003; Fuys, Geddes, & Tischler 1988; Geddes & Fortunato, 1993; van Heile, 1999). Level 0 is when children are in the early stages of distinguishing between circles, triangles, and squares. Level 1 is the visual level, in which students recognize shapes and form mental images. Level 2 is the descriptive and analytic level in which students recognize and characterize shapes by their properties. Level 3 has been called the “abstract relational
level” at which students form abstract definitions, determine necessary conditions for a concept, and provide logical arguments in the mathematical area of geometry. At Level 4 students can determine the differences among undefined theories and definitions and construct a proof based on the givens of the situation.

Van de Walle (2007) has disputed these levels because, he argued, they lack detailed description of students’ thinking, and there is uncertainty whether the identified stages accurately represent children’s mental representation of geometric concepts. This writer argued that children think about geometry in many different ways, and that students in the United States are not developing the levels of understanding necessary to truly understand geometric concepts (Van de Walle, 2007). Van de Walle details students’ development of geometric concepts in Table 1.

Learning to measure qualities in space, such as length, area, volume, and angle, provides practical opportunities for developing fundamental understandings of measurement concepts (Lehrer & Schaubue, 2000; Muir, 2006). Measurement is integrated throughout math and science curriculum yet has roots in everyday experiences (Clements, 2003; Clements & Battista, 1992; Lehrer & Schaubue, 2000).

Concepts of measure increasingly entail subdivisions of space that translate into subdivisions of measurement (Clements & Battista, 1992; Lehrer & Schaubue, 2000). These connections extend to other phenomena such as mass, time, and rate. These extensions are crucial to development of scientific reasoning (Clements & Battista, 1992; Lehrer & Schaubue, 2000). Piaget’s studies suggested that concepts of spatial measure were not unitary, but rather consisted of a web of related mathematical concepts (Lehrer
Table 1

Van de Walle's Geometric Developmental Stages

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Visualization</td>
<td>Children identify prototypes of basic geometrical figures (triangle, circle, square). They view figures holistically without analyzing their properties. At this stage children might balk at calling a thin, wedge-shaped triangle (with sides 1, 20, 20 or sides 20, 20, 39) a &quot;triangle&quot;, because it's so different in shape from an equilateral triangle. Squares are called &quot;diamonds&quot; and not recognized as squares if their sides are oriented at 45° to the horizontal. Children at this level often believe something is true based on a single example.</td>
</tr>
<tr>
<td>1 Analysis</td>
<td>Children can discuss the properties of the basic figures and recognize them by these properties, but might still insist that &quot;a square is not a rectangle.&quot; Children do not see the relationships between the properties. They might reason inductively from several examples, but not deductively.</td>
</tr>
<tr>
<td>2 Abstraction</td>
<td>Students begin to reason deductively. They understand the relationships between properties and can reason with simple arguments about geometric figures. They recognize that all squares are rectangles, but not all rectangles are squares, and they understand why. They can tell whether it is possible or not to have a rectangle that is, for example, also a rhombus.</td>
</tr>
<tr>
<td>3 Deduction</td>
<td>Learners can construct geometric proofs at a high school level. They understand the place of undefined terms, definitions, axioms and theorems.</td>
</tr>
<tr>
<td>4 Rigor</td>
<td>Learners understand axiomatic systems and can study non-Euclidean geometries.</td>
</tr>
</tbody>
</table>
& Schauble, 2000). The conceptual growth of the learner is tightly related to the overall
development of reasoning and counting (Lehrer & Schauble, 2000; Van de Walle, 2007).

Hiebert’s studies did not support Piaget’s findings (e.g., Hiebert, 1981a, 1981b).
Hiebert carried out an instructional study with first graders, and found that some first
grade students were able to conserve length when taught important beginning concepts of
length measure, such as iterating units (accumulating units by counting) to measure
length. Hiebert found that acquiring the idea of iteration was unrelated to a child’s level
of understanding as a conserver. The sole factor related to conservation was found to be
knowledge of inverse relationships between length of unit of measure and the smaller
units that make up this unit of measure.

Measure of distances requires reconstructing space so that successive units are
representative iterations of distances (Piaget, Inhelder & Szeminska, 1960). Children’s
first understanding of length measure involves direct comparison of objects (Lindquist,
1989; Piaget et al., 1960). The practical use of units is grounded in childhood experiences
involving observation of the use of rulers, measurement devices, and the use of these
devices in child play (Lindquist, 1989). The concept of measurement applies to math and
science yet has roots in everyday experiences (Lindquist, 1989). Learning to measure
qualities in space, such as length, area, volume, and angle provides practical opportunities
for developing fundamental understandings of measurement concepts (Lehrer, 2003). The
connection between measure and space extends into other math and science fundamentals
such as mass, time, and rate (Lehrer & Schauble, 2000). These types of extensions are
necessary to develop effective scientific reasoning skills (Lehrer & Schauble, 2000).
More recent studies continue to support the need for classrooms to emphasize representation and written communication of linear measurement which create opportunities for greater understanding of mathematical concepts (Cawley et al., 2009; Chappell & Thompson, 1999). Asking children to represent their experiences has helped them to discover guiding principles and lead to conceptual growth (Cifarelli, 1998; Moyer, 2001). Students that use concept images instead of concept definitions in their reasoning seem to retain their learning experiences (Clements, 2003). However, concept images have been found to be adversely affected by inappropriate instruction (Clements, 2003). The use of manipulatives in representing measurement and geometric concepts also needed to be correctly implemented in instruction for student learning to occur (Cass et al., 2003; Clements & Battista, 1992). Repeated experiences are also necessary for lasting understanding to occur (Confrey, 1995). The U.S. curriculum has lacked this type of manipulative use as compared to other countries like Japan (Clements & Battista, 1992).

According to Clements and Battista (1992), pictures can give students an immediate grasp of certain concepts, but they must be varied. Since children cannot manipulate pictures, they are not as beneficial as manipulatives. Manipulative pictures, such as graphic computer programs, may have been the most effective in facilitating a deep understanding of measurement and geometric concepts it has been argued (Clements & Battista, 1992; Maccini & Gagnon, 2000). A well-planned, thoughtful sequence of interactive activities along with teacher facilitation, have been necessary components of an effective math classroom (Clements & Battista, 1992).
Area and Perimeter Concepts

As a student reaches the upper elementary grades, area measure becomes differentiated from length measure and the surface-filling property of units becomes more apparent (Lehrer, 2003). Students in the middle grades (grades five to eight) often confuse area and perimeter concepts (Kidman & Cooper, 1997). Although students may be able to recall formulas for the area of a square or rectangle, Lehrer (2003) found that less than 20% of students in his study believed that area measure required identical units. Less than half of the students involved in this study could reconfigure a series of planar figures so that known area measures could be utilized to find the measure of an unknown figure (Lehrer, 2003). Muir (2006) found evidence that the conceptual understanding of area measure is often more difficult for students to grasp than the conceptual understanding of linear measure. However, when area and perimeter experiences presented in the mathematics classroom emphasized conceptual understanding, students were enabled to see area as the covering of the surface, rather than as a formula (Muir, 2006; Mulligan et al., 2005).

Changing the Instruction of Area and Perimeter

Change is necessary in teaching certain mathematical topics if true understanding is to occur (NCTM, 2000). According to May (1999), although area and perimeter have traditionally always been taught together, there is a need to teach about area before teaching the concept of perimeter. The concept of area should be introduced at the third and fourth grade levels when students are learning multiplication (May, 1999; Yeo, 2008). Van de Walle (2007) similarly argued that teaching perimeter should be
introduced after area and multiplication arrays, because it involves linear measurement. Research indicates that students have difficulty explaining and illustrating ideas of area and perimeter, even in the middle grades (Chappell & Thompson, 1999). Students often confuse the two ideas because they have been taught as a series of procedures (Chappell & Thompson, 1999; Yeo, 2008). One such procedure involves the number of units around a figure, while the other involves the number of units enclosed by the figure (Van de Walle, 2007). Changing the sequence of teaching these two concepts can help students to remember what operation to use when working with area and perimeter (May, 1999).

Manipulatives used to create arrays have been shown to help students calculate area, but this strategy often is not introduced until the fourth grade (Cass et al., 2003; Outhred & Mitchelmore, 2000). However, even when an array is created with manipulatives, Outhred and Mitchelmore found, 30% of the students still counted each individual part of the manipulative rather than multiplying the number of rows with the number of columns, an unfortunate finding since arrays are often used in the instruction of multiplication concepts. Lehrer (2003) discovered that some students transfer the thinking processes associated with arrays to nonpolygonal forms to find approximate solutions to area; this implied that mental reconstructing of a unit of arrays would be beneficial when used in a classroom that emphasized representation and mathematical dialogue (Lehrer, 2003; Maccini & Hughes, 2000; Maccini & Gagnon, 2000).

When formal procedures are arrived at by the student through exploration, the abstraction becomes clearer (Van de Walle, 2007). Similarly, Moyer (2001) found that introducing the math concept based on multiple representations and meanings in
contextualized problem situations leads to a greater understanding of the concept. It is therefore important to construct effective problem-solving situations and use these representations as tools for understanding the information and relationships of the problem (Cifarelli, 1998). Graeber (1999) noted that research tells us that there are different logical paths that lead to the same ideas. Similar experiences may lead to different yet valid ideas, but different models were found to help different students construct necessary foundations of mathematical concepts (Cass et al., 2003; Graeber, 1999; Maccini & Gagnon, 2000).

Perimeter and area are real-world concepts, noted Moyer (2001). Applying these concepts to various types of problems involving regular and irregular shapes has been found not only to encourage important mathematical explorations, but also to tie into authentic applications beyond the classroom (Wiest, 2005). It is therefore important to pose challenging problems that have several adaptations and extensions along with challenging questions, as noted by Wiest.

**Summary of Literature Review**

This review has used the findings of an extensive range of previous research studies to place the current study in context. It began by providing an overview of math reform in the U.S. and highlighting the importance of the teacher's role in contributing to the effectiveness of reform. The key findings of previous research regarding the essential characteristics of effective mathematics instruction were also discussed, and it was noted that reform-oriented problem-solving strategies have been shown to be more successful than traditional procedural-based instruction, for students generally. The review then
addressed the issue of whether problem-solving methods are effective for low-achieving math students, presenting a range of findings which indicate that although this strategy may benefit these students, it must be adapted to their special needs. The body of research evidence suggests that since traditional explicit teaching methods also offer particular benefits for low-achieving students, some combination of traditional and reform-oriented approaches to teaching mathematics might be most effective for low-achieving students, but this must be well planned to be successful. Finally, the literature review examined the available research evidence regarding the teaching of geometry and measurement, and specifically the concepts of area and perimeter, and it was concluded on the basis of the findings that there is considerable need for improvement in these areas to raise the performance of U.S. students.
CHAPTER 3

METHODOLOGY

This study explored the impact of integrating reform-based math curriculum with traditional math curriculum at the fifth grade level. The mathematical concepts of area and perimeter were the focus of the study. The instructional method took place over a three-week period and examined students’ understanding of the geometric and measurement concepts of perimeter and area, specifically focusing on students scoring below the 40th percentile on the Iowa Test of Basic Skills subtests of Mathematical Concepts and Estimation and Mathematical Problem-Solving and Reasoning. The study examined the students’ capabilities in applying concepts of area and perimeter in problem-solving situations and accurately computing area and perimeter problems. A secondary focus of this research study was changes in student self-perception as mathematical problem solvers after the implementation of area and perimeter problem-solving situations. The three research questions given below were the focus of this study:

Research Questions

1. What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner’s understanding of area and perimeter?

2. What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner’s self-perception as a mathematical problem-solver?
3. What impact does the teacher’s classroom structure when utilizing reform-based problems, have on struggling learners’ understanding of perimeter and area?

Each research participant completed a pretest and posttest dealing with the concepts of area and perimeter (see Appendix A). The pretest and posttest included problems involving calculations of area and perimeter and problems applying the concepts of area and perimeter. All participants completed a math attitude survey (see Appendix B). The attitude survey provided the researcher with background information on the students’ self perceptions of their mathematical ability. The 2 students identified as struggling learners for this research study participated in a task-based interview (see Appendix C) before and after the unit of instruction. These students were selected based on their Iowa Test of Basic Skills scores, which were below the 40th percentile on the Mathematical Concepts and Estimation and Math Problem-Solving subtests of this standardized test. Three other additional students were also asked to participate in the task-based interview, so as not to single out the students who were the focus of the descriptive case study. The 2 additional students were chosen randomly by the classroom teacher. The task-based interview gave the researcher a better understanding of the students’ knowledge of area and perimeter and any misconceptions they may have concerning these concepts. The researcher videotaped classroom instruction to make observations of the students selected for the case study and considered these findings when analyzing study results. All participants’ scores on the Iowa Test of Basic Skills Mathematical Concepts and Estimation and Mathematics Problem-Solving and Reasoning subtests were reviewed and compared as an additional source of data. This
research study was approved by the University of Northern Iowa Institutional Review Board effective March 23, 2009 (see Appendix F).

**Methodological Foundations**

The role of research is not necessarily to map and conquer the world but to add to the understanding of its current sophistication (Stake, 1995). Pursuit of a better understanding cannot be taught retrospectively (Denzin & Lincoln, 1994). Complex meanings seem to require continuous attention that goes beyond a checklist or survey (Denzin & Lincoln, 1994). Qualitative research allows the researcher to collect descriptive data in a natural setting focusing on the process rather than the outcome (Bogdan & Biklen, 2003). Qualitative research is naturalistic, emergent, and case oriented (Tomal, 2003). Theory-development by a researcher is an inductive process carried out to gain a better understanding of the interaction taking place before him or her (Bogdan & Biklen, 2003). These characteristics of qualitative research allowed the researcher to gain a better understanding of the impact on student learning which occurred during the implemented unit.

This research study utilized the qualitative research method of a descriptive case study. Compared to other methods, the strength of the case study method is the ability to examine an in-depth case within its real-life context (Yin, 2006). The descriptive case study method is best used when the research addresses an explanatory question often looking for a cause and effect relationship (Bogdan & Biklen, 2003). The researcher attempted to learn about student understanding of area and perimeter concepts with the use of problem-solving tasks within a traditionally taught classroom.
The descriptive case study method is beneficial in producing a firsthand understanding of the research questions allowing the researcher to make observations and collect data in real contexts (Bogdan & Biklen, 2003). Recognizing the context of the situation is a powerful way of gaining insight into the cause and effect relationship being studied (Cohen, Manion, & Morrison, 2007).

The descriptive case study, as defined by Bogdan and Biklin (2003), is a “detailed examination of one setting, or a single subject” (p. 54). Focusing on a single event or individual gives the researcher the opportunity to see the system studied as a whole rather than a loose connection of traits (Cohen et al., 2007). The descriptive case study can report dynamic and unfolding interactions of human relationships and events that take place (Bogdan & Biklen, 2003). Distinguishing the context of the study enables boundaries to be drawn around the case. This is done by referencing the characteristics of those individuals and groups involved and defining the participants’ roles and functions of the case (Cohen et al., 2007).

The descriptive case study method has several strengths to add to the validity of this study. The study and its results will be more easily understood by a wide audience because of the way it is written (Cohen et al., 2007). The descriptive case study in education catches unique features that may otherwise be overlooked in a larger data collection process (Cohen et al., 2007; Tomal, 2003). The descriptive case study also allows for insights into similar situations and cases, making the data and its conclusions applicable in a similar educational setting.
This case study presented data formally and explicitly, which distinguishes it from the case study narrative. In using pretests and posttests, and in comparing ITBS scores to gather information, this study gained supporting quantitative data. The pretest and posttest given served as a vehicle for providing information which guided the formulation of conceptualizations (Cohen et al., 2007). An intention of this study was to arrive at conceptualizations not only by analyzing descriptive data, but also by generalizing patterns that occur in all forms of the data collected: pretests and posttests, attitude surveys, task-based interviews, standardized test scores, and classroom observations.

**Sample and Setting**

The participants involved in the study were chosen based on students’ ages and the teacher’s utilization of problem-solving curriculum in mathematical instruction. The teacher and his classroom were chosen for this research study based on the teacher’s history and reputation within the district as an elementary mathematics teacher who utilizes several types of problem-solving activities within a traditional mathematics curriculum. The school district in which the study took place fits the profile desired by the researcher, a small school with increasing diversity in the student population and an increasing student population low in socio-economic status.

**Participants**

The participants in this study were fifth grade students from a small town school district in Iowa. The research sample was comprised of 24 students: 11 females and 13 males. Their fifth grade class is one of four sections in the school district. Of the 28 students in the classroom, two students have been identified as special education students.
and receive mathematics instruction from a special education teacher. All students of the fifth grade class and their parents were given student assent and parent consent forms before the beginning of the research study. Two students requested not to participate in the data collection of the research study. There are twenty four students participated in data collection of the research study. Students who scored below the 40th percentile on the math subtests of the Iowa Test of Basic Skills the previous school year made up the focus subgroup. The 40th percentile score was chosen because it has been determined by the Iowa legislation as the minimal level of student proficiency (No Child Left Behind Procedures, Guidelines, and Policy, 2006). The regular classroom teacher was a key participant in the research study. This teacher is a veteran teacher with approximately 20 years of experience in the elementary setting. The curriculum implemented by the teacher was based on a traditional unit of instruction aligned with the district’s established mathematic standards and benchmarks. Within the curriculum, the teacher used a variety of activities similar in characteristic to reform-based mathematics curriculum. The teacher has received no formal training in implementing reform-based mathematics curriculum.

The elementary principal was involved in providing student-related data which helped in verification of data. Prior to the research study, school district administration completed consent forms. All students in the fifth grade class receiving regular math instruction participated in all classroom activities, the pretesting, posttesting, and completion of the attitude survey. Two students made up Group 3 of the research study. The students in Group 3 were selected because their scores on the mathematical subtests
of the Iowa Test of Basic Skills were below the 40th percentile. Three additional students, scoring above the 40th percentile on the Iowa Test of Basic Skills mathematics subtests also participated in the task-based interview. These 3 additional students were interviewed so the 2 members of the Group 3 were not singled out.

Setting

The school district is comprised of approximately 1600 students in a small town setting. It includes two elementary schools, one middle school, one high school, and one alternative high school. According to the Iowa Department of Education website (http://www.iowa.gov/educate/index.php?option=com_docman&task=cat_view&grid=93 &Itemid=1563), approximately 90% of the student population in this district is White and 10% non-White (Black, Asian, Hispanic, and Native American). Special education students comprise 17% of the class participating in this study. The elementary building where the study took place includes two sections of fifth grade with a combined total of 52 students. Only one section of 28 students participated in this study. Within the district, 2.4% of the student population is categorized as Limited English Proficient students (LEP). However, the district's fifth grade class has no students categorized as LEP.

Approximately 40% of the district's total student population qualify for free and reduced lunch services, while 44.6% of the students at the elementary building that participated in this study were eligible for free and reduced lunch services.

Instrumentation

Multiple sources of evidence benefit descriptive case study research (Yin, 2006). By not limiting the research to a single source, the opportunity to establish converging
evidence through descriptions makes the study findings more robust, adding value to mathematics education (Denzin & Lincoln, 2003). The narrative of this case study is supported by quantitative data presented fairly and separately from the written narrative. Task-based interviews, classroom observations, pretests, and posttest scores, standardized test scores, and math attitude survey results were instruments used to establish and support the study’s findings.

**Performance-Based Task**

Performance-based tasks were used as part of a pretest and a posttest during the study. This form of assessment is familiar to the participating teacher and students of the study. This type of assessment contributes to the overall purpose of evaluation, the improvement of instruction and learning (Linn et al., 1991). Performance-based assessments involve the performance of tasks that are valued in the context of the curriculum (Linn et al., 1991). The Iowa Department of Education requires a second form of assessment from each school district besides the standardized assessment of Iowa Test of Basic Skills. *Exemplars*, a commercially created performance-based assessment, are the additional alternative form of assessment reported by the school district to meet this state requirement. Two of the questions on the pretest and posttest are characteristic of the performance-based assessments students are familiar with on Exemplars.

**Math Attitude Survey**

A math attitude survey was given to all student participants at the beginning and the end of the unit of study (see Appendix B). The researcher modified an attitude survey developed by Dutton and Blum (1968) to help establish self perception of the students
involved as mathematicians. Questions were adapted to meet the needs of the age level of the participants. Self perception is an important factor influencing students’ success when working on math problems (NCTM, 2000). It is likely students who feel positive about mathematics will achieve at higher levels than students with negative attitudes toward math (Reyes, 1984). Dutton and Blum’s original attitude survey has been modified and replicated in several studies on mathematical attitudes and dispositions. Reyes (1984) and Hong (1996) have used this survey as the basis for the tool developed to measure math dispositions and variables affecting mathematical achievement in elementary students. The attitude survey for this study included questions dealing with mathematical ability, usefulness of mathematics, and dispositions toward computational arithmetic and mathematical problem-solving. To make the interpretation of the final data understandable the researcher categorized attitude survey questions into three clusters. The three clusters focused on: (1) confidence as a problem solver, (2) enjoyment of doing mathematics, and (3) appreciation of mathematics.

Standardized Test Results.

The Iowa Test of Basic Skills scores on the subtests of Mathematical Concepts and Estimation and Mathematical Problem-Solving and Data Interpretation was also used as a source of data. This standardized test was used as an alternative form of data to establish the participants’ overall understanding of mathematical concepts and growth in understanding the mathematical concepts of area and perimeter. These concepts of measurement and geometry have applications across math and science, yet relate to authentic real life experiences beyond the classroom (Clements & Battista, 1992; Wiest,
The participants’ Iowa percentile rankings and national percentile rankings were also compared and analyzed. Specifically there is one question on the subtests dealing with the concepts of area and perimeter of the geometry and measurement standards of mathematics. Student responses to this item were reviewed to inform outcomes of the study.

**Task-Based Interview and Classroom Observations**

Any opportunity to gain information from students that bears directly on a classroom goal and can help answer research questions is central to gains in making instruction in education better (Bogdan & Biklen, 2003). The interview process can benefit overall the scientific goal of the theory of mathematics education, especially when the model is as explicit as possible (Cohen et al., 2007). Inferences made from the interview process depend on models and preconceptions about what we are trying to infer and its relation to the observable behavior (Goldin, 1998). It is necessary for the researcher to separate what is observed and inferences drawn from his or her observations. In observing a child’s verbal and nonverbal behavior, the goal is to infer something about children’s thought processes, problem-solving methods, and/or mathematical understandings (Goldin, 1998). The purpose of the task-based interview in math education is to allow us to characterize children’s strategies, knowledge structures, or competencies; to determine effectiveness of instruction; to understand developmental processes better; or to explore problem-solving behavior (Goldin, 1998).

Task-based interviews may have different interpretations since the observer may disagree about others’ inferences from scientifically described criteria to be used when
conclusions are drawn (Goldin, 1998). A theoretical framework is necessary to describe what is inferred. The theory must also tell something about how characteristics of the task in the task-based interview are expected to interact with the cognitive understandings which are inferred (Goldin, 1998). Understanding the contextual dependence of the interviews also means recognizing how difficult it is to establish criteria in advance for all inferences about the child’s cognition (Goldin, 1998; Tomal, 2003).

Theory will inevitably influence the observer. The context of the situation influence and place constraints on the interactions which take place during the interview, therefore influencing the inferences that are made by the researcher (Stake, 1995). It has been assumed by some that science is primarily factual and deals almost solely with facts, thus theory has no role in science (Davis, 1984). Careful observation of science reveals this to be false. Closer to the truth is the idea that facts are almost unable to exist except in the presence of an appropriate theory. Without an appropriate theory, one cannot state what the facts are (Davis, 1984). The question is to what extent the influence of theory remains tacit, taking place through unconscious assumptions of the researcher, or becomes explicit and open to discussion and challenge. It is necessary to proceed systematically with tasks explicitly described and designed to elicit behaviors that are to some degree anticipated (Davis, 1984). The task chosen for the task-based interview will focus on the relationship between the concepts of area and perimeter. This relationship is an area of confusion for many elementary students (May, 1999; Moyer, 2001).

Social and psychological context affects the interview’s interactions through internal representations that the child has constructed (Goldin, 1998; Stake, 1995). These
are considered contextual because semantic content of the representational systems involved is not derived from or related to mathematical representations associated with the task posed during the interview (Goldin, 1998; Stake, 1995). Other contextual factors influencing the interview include who conducts the interview (stranger or someone the child is familiar with), worth of the task (assessment or evaluation), and whether it is an open-ended task or has a right or wrong answer (Goldin). The child also brings influences to the interview, (Bogdan & Biklen, 2003; Goldin, 1998), such as being tired, alert, hungry, excited, or easily distracted. The importance the child ascribes to the problem also influences the outcome of the task and the aligned interview (Goldin, 1998). The child’s persistence, enthusiasm, choice of strategy, and so forth are necessary influences that need to be examined (Goldin, 1998).

Understanding the contextual dependence of the interviews and the classroom observations also means recognizing how difficult it is to establish criteria in advance for all inferences about the child’s cognition (Goldin, 1998). When observations are interpreted in context, new patterns may occur. The desire is to make the best conjectures possible and try to be explicit about the reasons for conjectures, including using relevant contextual factors, as these occur (Zang, 1994).

Data Collection

Data collection took place in the four phases described below.

Pretest

All students in the fifth grade class were given a test comprised of six questions (see Appendix A). Test items included traditional algorithmic calculation using area and
perimeter formulas and problem-solving situations requiring the application of area and perimeter concepts. Students were given a math attitude survey at the beginning of the unit of study.

**Video Tapes of Classroom Instruction**

Video tapes allowed the researcher to collect data by observing the classroom atmosphere, math lessons, and classroom dialogue. Lessons and activities directly observed by the researcher were selected based on topics being taught and their benefit to the study. All classroom instruction of the unit on area and perimeter was videotaped to ensure reliability of desired mathematics instruction. Videos were viewed by the researcher and anecdotal notes created.

**Task-Based Interviews**

Two students scoring below the 40th percentile on the ITBS math reasoning and problem-solving sections were given a task-based interview before and after the unit of instruction (see Appendix C). Two additional students, randomly chosen by the classroom teacher were also given the task-based interview as not to single out the subjects that were the focus of this descriptive case study.

**Posttest**

All students in the fifth grade class were given a posttest focusing on the concepts of area and perimeter. Test items included traditional algorithmic calculation using area and perimeter formulas and problem-solving situations requiring the application of area and perimeter concepts. A post attitude survey was also given to all students to
examine changes that may have taken place in students' self perception and disposition towards mathematics during the time of the study.

Data Analysis

During the course of a case study there is not one particular moment when data analysis begins. Analysis of collected information is a matter of giving meaning to first impressions as well as final compilations (Stake, 1995). In formulating any conclusions from the data, the analysis should take our impressions and observations apart and give meaning to the parts. Research involves more than finding a solution to a problem. It also encompasses discoveries of new facts and relationships concerning an unknown solution (Tomal, 2003).

The analysis of the study’s data included pre and posttest results, math attitude survey results, task-based interviews, previous standardized test scores, and anecdotal notes taken from video tapes of class instruction.

The attitude survey results were examined in aggregate for the entire group of participants, establishing any changes in students’ self-perceptions as a mathematician. Additionally, the results of the attitude survey taken by the students participating in the task-based interview were individually interpreted.

The goal of the task-based interviews was to gain an in-depth knowledge of students who struggle to develop understanding of the specific concepts studied. These interviews also gave the researcher insight into any individual misconceptions that occurred and helped establish any patterns and relationships in the misconceptions.
Anecdotal notes were made by the researcher during the viewing of the videotaped math classes. The world of education is subjectively structured and holds particular meanings for each of its participants (Cohen et al., 2007). The focus of the classroom video tapes was the 2 students identified as scoring below the 40th percentile on two sections of the math component of the Iowa Test of Basic Skills. The key focus of these observations from the video tapes was the behavior towards mathematics of the identified students and any background conditions that may influence subsequent analysis of the data.

Anecdotal notes made from videos of the math class and task-based interviews were analyzed qualitatively through a descriptive case study supported by pretest and posttest scores, attitude survey results, and prior standardized test scores.

All participating students were matched with their corresponding data by the classroom teacher randomly assigning a letter to each participant. The coding of the data helped ensure the privacy of the participant. The researcher gave pseudonyms to all students included in the results and discussion of the research study.
CHAPTER 4

RESULTS

In this chapter the researcher will describe the results of dissertation research examining the impact of instruction using reform-based mathematics problems integrated into a traditional unit of mathematics instruction. Specifically, this research study focused on two fifth grade students who struggle to learn mathematics (defined for this study as students scoring below the 40th percentile on the mathematics subtests of the Iowa Test of Basic Skills). The research involved the fifth grade teacher as the individual responsible for instruction, whereas the researcher collected data from students using multiple methods: pre and posttests, task-based interviews, student attitude surveys, Iowa Test of Basic Skills scores, and field notes from observations and video tapes of classroom instruction. Table 2 gives the timeline of research documentation and implementation.

The following is a descriptive case study, using both qualitative and quantitative data sources. Findings will be presented in four sections. In the first section the researcher describes a math lesson that illustrates the teacher's use of instructional time and the expectations for students. The researcher describes a lesson that is taught to a class of 26 students to establish the context for observations of the target students. Twenty-four students and their parents signed consent forms allowing the researcher to collect data and make observations pertaining to these students' work, tests, and class involvement. Two students chose not to take part in the research study. Data on these two students is not included in any research findings. Student names were randomly coded by the classroom teacher allowing the researcher to collect data and make observations
Table 2

Timeline of Research Documentation and Implementation

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>February, 2009</td>
<td>Iowa Test of Basic Skills given to subjects as fourth graders.</td>
</tr>
<tr>
<td>March, 2009</td>
<td>Internal Review Board approval of research study.</td>
</tr>
<tr>
<td>May, 2009</td>
<td>Research proposal approved. Attitude survey developed.</td>
</tr>
<tr>
<td>August, 2009</td>
<td>Participating school district administration approval. Unit developed.</td>
</tr>
<tr>
<td>October, 2009</td>
<td>Participating students assent and parents consent. Administration of pretest and pre attitude survey. Began implementation of unit. Student task-based interviews.</td>
</tr>
<tr>
<td>Mid-November, 2009</td>
<td>Administration of posttest and post attitude survey.</td>
</tr>
<tr>
<td>February, 2010</td>
<td>Iowa Test of Basic Skills given to subjects as fifth graders.</td>
</tr>
</tbody>
</table>

pertaining to these students' work, tests, and class involvement. The classroom teacher and students have been given pseudonyms to keep their identities confidential. The second, third, and fourth sections will address each research question individually supported by quantitative and qualitative data. Within each of the last three sections the researcher describes findings concerning the two fifth grade students who struggle to learn mathematics.

The researcher will refer to three groups of students when discussing the findings of this research study. Group 1 refers to the 26 students of the fifth grade receiving instruction during math class. Group 2 refers to the 24 students agreeing to share their data while taking part in the research study. Group 3 refers to the two students identified
as struggling to learn mathematics, making up the focus group. All students included in the results of the research study were assigned pseudonyms to ensure their privacy.

Questions on the pretest and posttest used to gain information for this research study were categorized into three groups: open-ended understanding, problem-solving, and calculation. Questions 1 and 2 (see Appendix A) on the pretest and posttest will be referenced in the open-ended understanding category. These two questions presented visuals of arrays and asked students to describe their knowledge of perimeter and area of the arrays. Questions 3 and 4 of the pretest and posttest will be referred to as problem-solving questions. The problem-solving questions gave perimeters and areas of two arrays, and the students were asked to give the dimensions of each array. Questions 5 and 6 focused on calculating the perimeter and area of two arrays given the dimensions in words. These two questions will be referred to as calculation questions.

**Findings**

When discussing the findings to research questions one, two, and three, the researcher will share Group 2 results, followed by Group 3 results.

**Traditional Math Lesson**

When the researcher observed and viewed videos of the classroom teacher’s instruction of a traditional math textbook lesson, class time was broken up into three tasks: skills warm-up, guided instruction, and independent practice. Time in class was allotted by Mr. Halverson during traditional math lessons as shown in Table 3. In observing classroom instruction and viewing video tapes of traditional instruction, Mr. Halverson specifically stated the math objective and wrote several example
Table 3

*Time Allocation of Traditional Math Lesson*

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Organization</th>
<th>Content/Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-8:40</td>
<td>1</td>
<td>Individual</td>
<td>Skills warm-up</td>
</tr>
<tr>
<td>8:40-9:00</td>
<td>2</td>
<td>Whole class</td>
<td>Guided instruction of skills or task</td>
</tr>
<tr>
<td>9:00-9:30</td>
<td>3</td>
<td>Individual</td>
<td>Work on assignment or task</td>
</tr>
</tbody>
</table>

problems on the board. Mr. Halverson worked through each of the six examples explaining his work and strategies, followed by giving the students similar problems to solve individually. Once the majority of students had completed the given examples, Mr. Halverson would call on volunteers to go to the board to show and explain their solutions. From the 10 classroom observations, the researcher viewed Mr. Halverson asking students to share their solutions and explaining their thinking process. The researcher did not observe either member of Group 3 volunteer to explain their results. After a class discussion of the student work and results, the teacher would give the assignment, clarify directions by answering any questions, and allow students to work independently on the assignment for the remaining time in the class period. Lessons involved mostly teacher direction and instruction, followed by students working independently. Mr. Halverson circulated among the students as they worked independently.
Reform-Based Lesson

Prior to the implementation of the area and perimeter unit, the researcher collaborated with Mr. Halverson in developing the sequence of lessons and high-lighting basic characteristics of reform-based curriculum. As the researcher observed in the classroom and viewed video tapes of the mathematics instruction, it was apparent that the participating teacher, Mr. Halverson, had planned lessons taking into consideration suggestions of the reform-based curriculum. The teacher selected a mathematically rich lesson which allowed students to explore and make sense of the mathematical objective of the lesson (National Research Council, 2001). The teacher facilitated student learning through questioning and discussion during small group interactions, followed by a whole class sharing session (National Research Council, 2001; Trafton & Midgett, 2001). During student exploration and sharing, the teacher reflected on students’ understandings and misconceptions (Trafton & Midgett, 2001). Mr. Halverson was observed during small group work circulating among the students during answering questions and asking students to clarify their thinking. Mr. Halverson often used clarifying questions to help students solidify their understanding or discover their misconceptions. Mr. Halverson would ask students to determine if any similarities existed among the area and perimeter problems given and encouraged the students to discover any patterns that may occur. These types of questions led students to construct understanding of area and perimeter through discovery, rather than the teacher simply telling the students the necessary information needed to calculate area and perimeter. Student questioning allowed Mr.
Halverson to informally assess student understanding. Students continuously responded to his questions creating the opportunity for him to assess students in their understanding.

All lessons observed and viewed from videos included whole class discussion and pair or small group work. When students were given time for independent practice, the time given ranged from 5 to 10 minutes in length. Mr. Halverson circulated among the students during small group work and independent practice. He was observed in each of the 10 videos viewed by the researcher complimenting students on their work and asking questions of students who were struggling. The researcher observed Mr. Halverson talking with Larry, Group 3 member 1, four times during small group work and independent practice. Mr. Halverson was observed talking with Karen, Group 3 member 2, five times during small group work and independent practice. Table 2 shows how the teacher conducted a problem-based lesson from a reform mathematics curriculum. This was typical of how Mr. Halverson, the classroom teacher, used his time during most lessons for mathematical learning involving reform-based problem-solving tasks.

The lesson presented in Table 3 began with the next part of an ongoing investigation that included exploring and recording student solutions when solving a problem with a fixed perimeter but varying areas. The mathematical goal of the problem was for students to explore and learn that areas of rectangles with a fixed perimeter can vary considerably. The following problem was posed to students:

*Suppose you wanted to help a friend build a rectangular pen for her dog, Shane. You have 24 meters of fencing, in 1-meter lengths, to build the pen. Which rectangular shape would be best for Shane?*

*Using your color tiles, find all possible rectangles with a perimeter of 24 meters. Sketch each rectangle on grid paper. Record your data about each possible plan in a table with these column headings:*
Students were allowed, but not required, to use color tiles and grid paper to explore possible solutions in the second part of the lesson. The researcher observed both members of Group 3 using color tiles while working on a solution to the problem. Students worked each day in the same groups determined by the desk arrangement in the classroom. Students recorded work individually on the given grid paper which was stapled into their math journals.

Very clear expectations were given by Mr. Halverson during class discussions and for expected behavior when getting manipulatives for group work. Students were given verbal warnings for inappropriate behavior when not meeting expectations when gathering needed materials. Mr. Halverson also gave expectations about what was appropriate in a quality math journal. Students as a class were publicly complimented on their neatness and organization of their math journals.

In observing classroom instruction and viewing video tapes of instruction, Mr. Halverson went over the expectations of the problem to be solved in all 10 lessons viewed. During seven of the lessons viewed, one student was chosen to read the problem aloud. The researcher did not observe either member of Group 3 reading a problem aloud. This was followed by Mr. Halverson clarifying questions from the class to make sure the problem presented was understood by everyone. The following is an example of Mr. Halverson introducing a problem-solving situation.

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Perimeter</th>
<th>Area</th>
</tr>
</thead>
</table>

(Lappan et.al., 2002, p. 36)
Table 4

*Time Allocation of Whole Class Reform-Based Lesson*

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Organization</th>
<th>Task/Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-8:35</td>
<td>1</td>
<td>Whole group</td>
<td>Skills warm-up.</td>
</tr>
<tr>
<td>8:35-8:45</td>
<td>2</td>
<td>Whole group</td>
<td>Class discussion of previous problem and findings; explaining next problem or activity.</td>
</tr>
<tr>
<td>8:45-9:05</td>
<td>3</td>
<td>Small grps./Pairs</td>
<td>Exploration of assigned problem or activity.</td>
</tr>
<tr>
<td>9:05-9:10</td>
<td>4</td>
<td>Small grps./Pairs</td>
<td>Continued exploration of problem or task; or small groups circulating and evaluating other groups' results.</td>
</tr>
<tr>
<td>9:10-9:25</td>
<td>5</td>
<td>Whole group</td>
<td>Class discussion of small groups' solutions and results.</td>
</tr>
</tbody>
</table>

which was part of a reform mathematics problem implemented during the unit of instruction for this research study. The dialogue that follows was derived from viewing videos of class instruction:

Mr. Halverson: Today we have a new task to work on. Aubrey, will you please read Problem 4.1?

Aubrey: Suppose you wanted to help a friend build a rectangular pen for her dog, Shane. You have 24 meters of fencing, in 1-meter lengths, to build the pen. Which rectangular shape would be
best for Shane? Using your color tiles, find all possible rectangles with a perimeter of 24 meters. Sketch each rectangle on grid paper. Record your data about each possible plan in a table with these column headings: length, width, perimeter, and area.

Mr. Halverson: Here is your fencing (color tiles) that you will use to solve this problem. What shapes do you have to make?

Kylie: Rectangles

Mr. Halverson: Where does it say that? Do we have to make rectangles? Could we make a square?

Kylie: Yes.

Mr. Halverson: Why?

Eric: Because a square is a rectangle.

Mr. Halverson: What is the information you need to remember to solve this problem?

Derrick: There are 24 meters for fencing....the outside or perimeter.

Mr. Halverson: Right. It doesn’t matter how big or how little your rectangle, the perimeter always has to be 24. You will want to make a chart similar to the one on the chalkboard. What will you label your columns?

Students: Length....width.....perimeter....area

Mr. Halverson: Correct, those four things. You will need a number to
identify your designs, so we will need to add that to your chart. Your charts should be made neatly and completed in your math journal.

Emily: Can you make more than one design?

Mr. Halverson: Yes, you can.

Following this conversation, the students worked in small groups to solve the problem. Students who were struggling, including one member of Group 3, were given suggestions of possible shapes of solutions and specific expectations about how to organize their solutions to the problem.

The final activity for the lesson involved a whole class discussion of the students' findings. From viewing the video tape, Mr. Halverson realized the students took more time to solve the problem than anticipated but still wanted to discuss solutions. Reform-based curriculum provides guidance to the teacher with questions that encourage student reflection and promote meaningful discourse during and after exploration of the problem (Trafton et al., 2001). Mr. Halverson had one small group share their results which he discussed and wrote outcomes on the board with the class. Through this problem and the class discussion that followed, students were able to discover the mathematical concept of constant perimeter/changing area: changing the length and width will change the area of the rectangle but not necessarily the perimeter.

The lesson previously described illustrates features of classroom instruction observed more than once by the researcher: group work, including whole class and small group work; student talk; and teacher expectations. When using a problem-based task in
mathematics instruction, Mr. Halverson allotted approximately half of the class time each for whole group work and small group work. Lessons included lengthy discussions of students' solutions to problems and the route students took to reach their solutions.

**Research Question 1**

The first research question asked, "What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner's understanding of area and perimeter?" For this question, two conceptual ideas of mathematic instruction were the focus: (1) area and perimeter which are particular topics of mathematics in which students often lack a solid conceptual understanding (Clements, 2003); and (2) the teaching of mathematics to struggling learners in authentic and meaningful contexts, including the teacher directly modeling problem-solving strategies, sequencing instruction, and giving students opportunities to communicate their mathematical understanding (Sherman et al., 2009).

Pre and posttests implemented before and after the unit of instruction and scores of the mathematics subtest of the Iowa Test of Basic Skills provided the necessary data to answer the first research question. A paired sample t-test was used to analyze the pre and posttest results. A paired sample t-test (also called a dependent t-test) compares the means of two scores from related samples (Cronk, 2004). The pre and posttests were given to students in Group 1, who all received regular classroom instruction by the participating fifth grade teacher. Two students in the sample requested not to have their test results included in the research data. Findings of Group 2 exclude any results gained from these two students' work. Group 3 was made of two students who struggle learning
mathematics, defined for this study as students scoring below the 40th percentile on the mathematics subtest of the Iowa Test of Basic Skills. These two students, Larry and Karen, scored below the 40th percentile and received mathematics instruction in the regular math class without additional supplementary mathematics instruction or curriculum from a special education teacher.

Test items dealing with area from the math subtests of the Iowa Test of Basic Skills were analyzed to answer the first research question. Test item scores from the students’ fourth grade year were compared to similar test item scores from the students’ fifth grade year.

Field notes from video tapes of the mathematics instruction in the fifth grade classroom during the instruction of the unit on area and perimeter were used to provide additional information concerning the first research question.

**Group 2 Pretest Results of Problems Calculating Area and Perimeter: Questions 5 and 6**

Students in the regular mathematics classroom took the pretest dealing with area and perimeter (see Appendix A). Calculating area and perimeter questions on the pretest pertained to the first research question. Figure 1 gives the two questions on the pretest and posttest focusing on accuracy in calculating area and perimeter. These two questions asked students to calculate the perimeter and area of an array given the dimensions of the array with no visual. The array’s dimensions were given in word form rather than numerals. Each question was worth 2 points for a total of 4 points. The students received 1 point for accurately calculating the area and giving a correct label and a separate point for accurately calculating the perimeter and giving a correct label. Mr. Halverson, the
regular classroom teacher scored the pretest and the researcher reviewed the assigned scores to eliminate teacher bias.

<table>
<thead>
<tr>
<th>Given the following dimensions of an array, calculate the area and perimeter. Make sure you label answers correctly.</th>
</tr>
</thead>
</table>
| 5. Length: nine inches  
  Width: eleven inches |
| 6. Length: twelve inches  
  Width: five inches |

*Figure 1: Pretest and Posttest Problems Calculating Area and Perimeter*

Question 5 involved an array with a length of 9 inches and a width of 11 inches. Question 6 involved an array with a length of 12 inches and a width of 5 inches. The average score for these questions on the pretest was .81 ($SD=1.11$) points out of 4 possible points. Over half the class, 14 students, scored 0 points. The highest score on this pair of questions was 3.5 points, obtained by one student.

Students scoring 0 points on questions 5 and 6 on the pretest had a range of responses. Several students drew pictures of arrays to help them compute their calculations. Some pictures were drawn with the wrong number of squares leading to miscalculations (see Figure 2), and other pictures were drawn correctly, but those students still answered the questions incorrectly (see Figure 3). Seven of the students left these questions blank on the pretest. Of the seven students who left the questions blank, five were able to make an attempt at calculating area and perimeter when given a similar question on the pretest that gave a visual of an array rather than the dimensions only.
Two students stated they did not know how to do questions 5 and 6. These same two students gave partially correct responses to questions 1 and 2 on the pretest. This pair of questions gave a visual of an array rather than the dimensions only.

Given the following dimensions of an array, give the area and perimeter. Make sure you label your answers correctly.
Length: nine inches
Width: eleven inches

Figure 2: Sample of student work with arrays incorrectly drawn for question 5.

Given the following dimensions of an array, give the area and perimeter. Make sure you label your answers correctly.
Length: nine inches
Width: eleven inches

Figure 3: Sample of student work with arrays correctly drawn for question 5.
Nearly half of the 24 students participating in the study answered some part of pretest questions 5 and 6 accurately. Student responses were in one of the following categories: (a) correctly calculated the perimeter of the given array but mislabeled the answer, (b) did not give accurate labels to the answers, or (c) did not identify which calculation was area and which was perimeter. Questions 1 and 2 refer to similar concept goals but are different in question format. The first two questions are open-ended and include a visual of an array. Table 5 shows student responses to questions 5 and 6 of the pretest.

Group 2 Posttest Results of Problems Calculating Area and Perimeter: Questions 5 and 6

All 24 students completing the pretest also completed the same posttest. The posttest was given by the regular classroom teacher, Mr. Halverson, at the completion of the unit of study on area and perimeter integrating reform-based mathematics problems within a traditional unit of mathematics instruction. Calculating perimeter and area questions on the pretest and posttest served as data in answering research question 1. These two questions were scored by the regular classroom teacher and allocated the same number of points as allotted on the pretest. The researcher reviewed the assigned scores to eliminate teacher bias. Students were able to score a maximum of 4 points on questions 5 and 6 of the posttest.

The average score on calculating perimeter and area questions on the posttest was approximately 3.08 (SD = 1.01) points of a maximum of 4 points: an increase of approximately 2.2 points. Approximately 66.6% of the students scored a 3 or 4 on the
Table 5

*Pretest Frequencies for Questions 5 and 6: Calculating Area and Perimeter*

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Number of students with score</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>14</td>
<td>58.3</td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.0</td>
<td>3</td>
<td>12.5</td>
</tr>
<tr>
<td>1.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2.0</td>
<td>5</td>
<td>20.8</td>
</tr>
<tr>
<td>2.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>3.0</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>3.5</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Total= 24  Total 100%

*N= 24*

posttest. Twelve of the students received the maximum of 4 points, accurately calculating and labeling their answers given the dimensions of an array. Two of the 11 students scoring 4 points included a drawing of the array with their answers. Others scoring 4 points on the two questions included only their calculations correctly labeled.

All students scored a minimum of one point on the posttest. The 25% of students who received a score of 1 or 2 were more likely to give an incorrect answer for the perimeter of the array than the area of the array. One of the students included a drawing with their answer but drew arrays with inaccurate dimensions. The answers given by this student for area and perimeter were not correct. Each question was worth 2 points for a total of 4 points. The students earned 1 point for accurately calculating the area and giving a correct label and a separate point for accurately calculating the perimeter and giving a correct label. The regular classroom teacher scored the pretest and the researcher
reviewed the given scores to eliminate teacher bias. Table 6 provides the frequencies and percents of total points earned on posttest items 5 and 6. Table 7 shows a comparison of student responses on questions 5 and 6 from pretest scores and posttest scores.

Table 6

*Posttest Frequencies for Questions 5 and 6: Calculating Area and Perimeter*

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Number of students with score</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.0</td>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>1.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2.0</td>
<td>4</td>
<td>16.8</td>
</tr>
<tr>
<td>2.5</td>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>3.0</td>
<td>5</td>
<td>20.8</td>
</tr>
<tr>
<td>3.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.0</td>
<td>11</td>
<td>45.8</td>
</tr>
</tbody>
</table>

Total= 24 Total = 100%

N = 24

Table 7

*Pretest/Posttest Comparisons for Questions 5 and 6: Calculating Area and Perimeter*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Cumulative</td>
<td>24</td>
<td>0.0</td>
<td>3.5</td>
<td>.81</td>
<td>1.11</td>
</tr>
<tr>
<td>questions 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest Cumulative</td>
<td>24</td>
<td>1.0</td>
<td>4.0</td>
<td>3.08</td>
<td>1.01</td>
</tr>
<tr>
<td>questions 5 and 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Group 2 Results of Paired Sample Test

Mean results of pretest and posttest calculation questions were compared using a paired sample \( t \)-test. A mean score of -2.27 (\( SD = 1.29 \)) was found in comparing pretest and posttest results. The average student score increased by approximately 2 points from pretest to posttest. The paired differences of the pretest and posttest results at a 95% confidence interval ranged from a lower level of -2.81 to a higher level of -1.73 resulting in a \( t \)-value of approximately -8.66 with a statistically significant level of .001. Ninety-five percent of the student samples have an average increase between 2.81 points and 1.73 points. There was a statistically significant increase in mean scores from pretest to posttest, \( t(23) = -8.66, p < .001 \). The effect size was 2.14. Table 8 shows the paired sample \( t \)-test of questions 5 and 6 on the pretest and the posttest.

Group 2 Results of ITBS Data

Scores of Group 2's Iowa Test of Basic Skills subtests obtained during their fourth grade year and their fifth grade year were compared. The unit of instruction

Table 8

<table>
<thead>
<tr>
<th>( N )</th>
<th>( df )</th>
<th>( Mean )</th>
<th>( SD )</th>
<th>( t )</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>23</td>
<td>-2.27</td>
<td>1.29</td>
<td>-8.66</td>
<td>.001</td>
</tr>
</tbody>
</table>
teaching area and perimeter was implemented during the time period between the ITBS tests. The National Standard Score (NSS) of the Iowa Test of Basic Skills was used to make the comparisons. This score is used to measure individual growth by providing a score on a developmental scale across different levels and forms of the test. The students’ results on the Concepts and Estimation subtest were compared along with one item dealing with area computation from that subtest.

The mean NSS of Group 2’s fourth grade Concepts and Estimation subtest results was 213.13 ($SD = 21.22$). Group 2’s fifth grade mean of the same subtest was 222.04 ($SD = 16.33$). Mean results of the fourth grade and fifth grade NSS of the Concepts and Estimation subtests were compared using a paired sample $t$-test. The mean score was -8.92 ($SD = 16.04$). There was an average increase of approximately 9 points on students’ NSS scores of the ITBS Concepts and Estimation subtest. The paired differences of the two scores in this comparison at the 95% confidence level ranged from a low score of -15.689 to an upper score of -2.145 resulting in a $t$-value of approximately -2.724, $t(23) = -2.724$, $p < .012$. There was a statistically significant increase in student scores on the ITBS Concepts and Estimation subtest. The effect size was -.23.

When using a paired sample $t$-test to compare results of the specific test item referring to area, the mean was found to be .042 ($SD = .55$). When analyzing one test item referencing the concept of area there was an average decrease in mean scores of .042. The paired differences of the two scores in this comparison at the 95% confidence level ranged from a low score of -.191 to an upper score of .274. The resulting $t$-value was approximately .371 with a significance level of .714, $t(23) = .371$, $p < .714$. The
difference between the mean score decreased and was not a statistically significant change.

**Group 3 Results Calculating Area and Perimeter: Questions 5 and 6**

The students making up Group 3 of this study were 2 fifth grade students who struggle learning mathematics. Students who struggle to learn mathematics was defined for the research study as scoring below the 40th Iowa percentile rank on the Iowa Test of Basic Skills in the mathematics subtests. Larry (male) and Karen (female) make up Group 3. Neither of the students received additional mathematics instruction or support outside the regular math class from a special education teacher during the school year prior to this study or the school year during this research study.

**Group 3 Member 1: Larry**

Larry is a quiet male fifth grade student. Based on the researcher's observations, Larry was polite and respectful to the classroom teacher and other students. Larry was never observed volunteering during whole class discussions and only shared when he was called on by the classroom teacher. When working in small groups or with a partner, Larry asked questions of his peers about the problem and directions but offered little to the discussion in completing the task. Larry's fourth grade IPR, NPR, and NSS on the ITBS subtests are given in the Table 9.

Larry scored 0 points on pretest questions 5 and 6 focusing on calculating area and perimeter given the dimensions of an array in written form. Larry gave incorrect answers for perimeter calculations but gave no response for area calculations.
On question 5 of the posttest Larry scored 0 points out of 2 possible points when asked to calculate the area and perimeter given dimensions of an array. On question 6

Table 9

**Group 3 Member 1 (Larry) Fourth Grade ITBS Data**

<table>
<thead>
<tr>
<th>Concept &amp; Estimation Subtest</th>
<th>Problem-Solving &amp; Data Subtest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSS</td>
<td>188</td>
<td>167</td>
</tr>
</tbody>
</table>

Larry correctly calculated and labeled the area given the dimensions of the array, but incorrectly calculated and labeled the perimeter. Larry’s fifth grade IPR, NPR, and NSS on the ITBS subtests are given in the table 10.

Table 10

**Group 3 Member 1 (Larry) Fifth Grade ITBS Data**

<table>
<thead>
<tr>
<th>Concept &amp; Estimation Subtest</th>
<th>Problem-Solving &amp; Data Subtest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSS</td>
<td>197</td>
<td>181</td>
</tr>
</tbody>
</table>

When comparing Larry’s ITBS Reading Comprehension subtest NSS scores to his Mathematics Concepts and Estimation subtest NSS scores he showed growth in both
areas. There was a larger increase of scores, from fourth grade to fifth grade on the Mathematics Concepts and Estimation subtest. Larry's ITBS NSS scores on this Math subtest increased by 9 points and his Reading subtest NSS scores increased by 3 points. A typical growth on the NSS scores of the ITBS scores for this age level is 14 points (www.aea267.k12.ia.us/idm/files/day4/day4_training/day3_status_growth.pdf).

Group 3 Member 2: Karen

Karen is a polite, social female fifth grader in the student sample. Based on the researcher's observations when viewing classroom instruction, Karen was on task during classroom instruction. Karen worked with other students in the class when asked to work in small groups or with a partner. In viewing videos of classroom instruction, Karen volunteered an answer three times during whole class discussions and would offer her thinking and solutions during small group work. Karen's fourth grade Iowa Test of Basic Skills subtests are given in Table 11.

Table 11

*Group 3 Member 2 (Karen) Fourth Grade ITBS Data*

<table>
<thead>
<tr>
<th></th>
<th>Concept &amp; Problem-Solving &amp; Data Subtest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSS</td>
<td>196</td>
<td>191</td>
</tr>
</tbody>
</table>
On the unit pretest Karen scored 1 out of 4 possible points on questions 5 and 6 focusing on area and perimeter calculations. A correct response was given for each problem, but her solutions were not labeled or identified as area or perimeter.

Karen’s score on the unit posttest was 2 out of 4 possible points, correctly calculating and labeling the area of the given array. Karen attempted but incorrectly calculated the perimeter of each problem. Karen’s answers to the perimeter problems were labeled correctly. Karen’s fifth grade National Standard Score on the ITBS subtests are given in Table 12.

When comparing Karen’s ITBS Reading Comprehension subtest NSS scores to her Mathematics Concepts and Estimation subtest NSS scores she showed growth in Math, but her scores decreased in Reading Comprehension. There was an increase

Table 12

*Group 3 Member 2 (Karen) Fifth Grade ITBS Data*

<table>
<thead>
<tr>
<th>Concept &amp; Estimation Subtest</th>
<th>Problem-Solving &amp; Data Subtest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSS</td>
<td>214</td>
<td>201</td>
</tr>
</tbody>
</table>

of 18 points from fourth grade to fifth grade on the Mathematics Concepts and Estimation subtest. Her NSS scores for Reading Comprehension decreased by 17 points.
Group 3 Results Open-Ended Area and Perimeter Knowledge: Questions 1 and 2

The open-ended questions on perimeter and area knowledge of the unit pretest and posttest (see Appendix A) asked students to explain everything they knew about the area and perimeter of a given array. Figure 6 illustrates the open-ended questions of the pretest and posttest. A visual of the array was given for each problem. Larry scored 0 points out of a possible 10 on questions 1 and 2 of the pretest and Karen scored 5 points out of the possible 10 points on the same questions. Given the same questions on the posttest, Larry scored 9 out of 10 points possible and Karen scored 10 out of 10 points possible. The regular classroom teacher scored these problems on the pretest and posttest.

The researcher reviewed the points assigned to eliminate teacher bias. Students were evaluated on their ability to identify the necessary dimensions of the array, explain how to calculate the perimeter and area of the given array, and use correct labels when giving solutions to area and perimeter problems.

Group 2 Pretest Results of Problem-Solving Questions 3 and 4

All students in Group 2 took the pretest. Items three and four of the pretest asked students to find the length and width of each array given the perimeter and area. Figure 7 shows questions 3 and 4 of the pretest and posttest. Students were allowed to use color tiles in solving items three and four if they chose. Each question was worth 2 points for a total of 4 points. The students received 1 point for accurately finding the length and 1 point for accurately finding the width of the array in each problem. Mr. Halverson, the regular classroom teacher, scored the pretest with the researcher reviewing the assigned scores to eliminate teacher bias.
Question 3 involved finding the length and width of an array with a perimeter of 18 inches and an area of 20 square inches. Question 4 involved finding the length and width of an array with an area of 18 square inches and a perimeter of 18 inches. The average combined scores for questions 3 and 4 on the pretest was 17. Only three students

1. Explain everything you know about the area and perimeter of the following array.

2. Explain everything you know about the area and perimeter of the following array.

*Figure 4: Pretest and Posttest Open-Ended Area and Perimeter Problems*

received points on these two questions on the pretest, the remaining 21 students received a score of 0. The responses given by the students receiving points included partially correct answers as compared to students receiving 0 points, whose results included no correct solutions. All but one of the students gave some type of solution and eight of the
students included a drawing of tiles in an attempt to find correct solutions. Pretest frequencies for questions 3 and 4 of the pretest are given in Table 13. The mean score of questions 3 and 4 on the pretest was approximately .167 ($SD = .38$).

Problems 3 and 4 give the perimeter and area of an array. Find the length and width of each array and prove to me why you think your answer is the correct solution. You may use color tiles to help you find the answers to these problems. Each color tile is one square inch.

3. Find the length and width of an array that has a perimeter of 18 inches and an area of 20 square inches.

4. Find the length and width of an array that has an area of 18 square inches and a perimeter of 18 inches.

**Figure 5: Pretest and Posttest Problems Applying Area and Perimeter Concepts**

**Group 2 Posttest Results of Problem-Solving Questions 3 and 4**

All 24 students completing the pretest also completed the same posttest. The posttest was given by the regular classroom teacher at the completion of the unit of study on area and perimeter integrating reform-based mathematics problems within a traditional unit of mathematics instruction. Problem-solving items of the pretest and posttest pertained to finding the length and width of an array when given the area and perimeter. The data from these questions was used in answering research question two. The two questions were scored by Mr. Halverson and were allotted the same number of points on the pretest. Students were able to score a maximum of 4 points on questions 3 and 4.
on the posttest. The researcher reviewed the scores given by Mr. Halverson to eliminate teacher bias. One discrepancy occurred, but Mr. Halverson explained his reasoning in giving the final score, and no changes were made on the assigned points.

Students taking the posttest scored on average 3.23 ($SD = .98$) points out of 4 total points possible. Responses on the posttest improved, with only one student not improving. All student responses on these two posttest items received at least 2 of the 4 points possible. Many students' scores reflected losing one half of a point for an incorrect label. Approximately one-third of the students used a drawing to help them find a solution. Students were allowed to use color tiles to solve the posttest items. More students may have used color tiles but chose not to include a drawing representing the color tiles as part of their solution. Of the students who included a drawing of the array in

Table 13

Pretest Frequencies for Area and Perimeter Problem-solving: Questions 3 and 4

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Total number of students with score</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>20</td>
<td>83.3</td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.0</td>
<td>4</td>
<td>16.7</td>
</tr>
<tr>
<td>1.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>3.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>3.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

$N = 24$
their item response, one student did not receive points because of inaccurate dimensions, whereas all others used accurate dimensions with their drawings. The other students who included a drawing in their response lost partial points because of inaccurate labels on their answers. The remaining two-thirds of student responses gave the dimensions with no visuals or drawings shown as part of their solution. The frequencies of student responses are given in Table 14.

**Group 2 Results of Paired Sample Test**

Mean results of pretest and posttest problem-solving questions were compared using a paired sample *t*-test. A mean score of -3.06 (SD=1.16) was found in comparing pretest and posttest results. The difference in mean scores increased by approximately three points. The paired differences of the pretest and posttest results at a 95% confidence interval ranged from a lower level of -3.55 to an upper level of -2.57 resulting in a *t*-value of approximately -12.89. The degrees of freedom value was 23 and a significance level of .001 was found. The difference between the means is statistically significant. The effect size was 4.12. Table 15 gives the results of the paired samples *t*-test calculated on questions three and four, *t*(23) = -12.89, *p* < .001.

**Group 3 Members**

The students making up Group 3 of this study were 2 fifth grade students who struggle learning mathematics. Students who struggle to learn mathematics was defined for the research study as scoring below the 40th Iowa percentile rank on the Iowa Test of Basic Skills in the mathematics subtests. Group 3 consists of Larry (male) and Karen (female). Neither of the students receive additional mathematics instruction or support
outside the regular math class from a special education teacher during the school year prior to or the school year during this research study.

**Group 3 Member 1**

Larry scored 0 points out of 4 points possible on the pretest when answering questions 3 and 4 (see Appendix A) dealing with area and perimeter in a problem-solving

Table 14

*Posttest Frequencies for Area and Perimeter Problem-solving: Questions 3 and 4*

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Number of students with score</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1.5</td>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>2.0</td>
<td>2</td>
<td>8.4</td>
</tr>
<tr>
<td>2.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>3.0</td>
<td>10</td>
<td>41.6</td>
</tr>
<tr>
<td>3.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>4.0</td>
<td>10</td>
<td>41.6</td>
</tr>
</tbody>
</table>

Total = 24

Total = 100%

Table 15

*Pretest/Posttest Paired Samples T-Test for Questions 3 and 4*

<table>
<thead>
<tr>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>Sig.(Two-Tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.06</td>
<td>1.16</td>
<td>-12.89</td>
<td>.001</td>
</tr>
</tbody>
</table>
questions 3 and 4 (see Appendix A) dealing with area and perimeter in a problem-solving situation. Problem-solving questions on the pretest and posttest asked students to give the length and width of an array when provided the perimeter and area. Larry made no attempt to solve these questions on the pretest leaving them blank. On the posttest Larry scored 3 points out of a possible 4 points on the same questions. Larry provided drawings with accurate dimensions and correct solutions. No labels were provided so 1 point was not awarded.

Group 3 Member 2

Karen scored 0 points out of 4 points possible on the pretest when asked to find the length and width of an array given the perimeter and area. Karen gave incorrect dimensions for question 3 and no response for question 4. On the posttest Karen scored 0 points on questions 3 and 4. Karen made an attempt to solve both problems, drawing an array with no given dimensions and gave incorrect answers for both questions.

Task-Based Interview

Group 3 members were individually given a problem-solving task (see Appendix C) to complete while the researcher made observations of their thinking and asked clarifying questions. Three other students from Group 2 were also given the task-based interview so as not to set the 2 members of Group 3 apart. The researcher read the expectations and the problem using a script (see Appendix D) to increase the reliability of the results of the task-based interviews. The task-based interview dealt with increasing the area of a rectangular shaped garden and the effect the change in area would have on the garden’s perimeter.
Group 3 Member 1: Larry

The researcher and Larry sat at a table outside the classroom in an open hallway to complete the task-based interview. When presented with the task, Larry was easily distracted by noise when others passed in the hallway. After the researcher read the problem (see Appendix C), Larry was not sure what he needed to do to solve the problem. The researcher suggested using color tiles to show the original garden size and then asked Larry to restate what the problem was asking. Larry was not able to do this. The problem was asking: “Can the size of the garden change, without changing the perimeter?” The researcher had to ask several clarifying questions to help Larry understand what the problem was asking. Larry was able to add color tiles to increase the size of the garden and assumed the perimeter would increase since the area increased. Overall, Larry was unsuccessful at reaching a conclusion to the task presented and eventually gave up. When asked by the researcher about the difficulty of the problem, Larry stated the problem was very difficult.

Group 3 Member 2: Karen

The researcher and Karen, Group 3 member two, completed the task-based interview directly outside the regular classroom in the hallway. During the task-based interview Karen was focused and on-task. Once the problem was introduced by the researcher, Karen immediately built the original garden using color tiles. After this Karen began to reread the problem herself and then asked the researcher to clarify what she needed to do next. The researcher asked Karen guiding questions allowing her to begin to solve the problem. Karen was not hesitant to ask questions and seemed relaxed and
comfortable working on the problem. Karen randomly built different gardens using color tiles. When calculating the area and perimeter of each garden arrangement, Karen counted the color tiles to get her answers. After several minutes of thinking silently, Karen reached a solution stating that the area of the garden could be increased and the perimeter would not have to change, but she was unable to give a reason why when asked by the researcher for her explanation. Karen’s solution was correct, but she showed no evidence of how she reached her solution.

Summary for Question 1

The first research question sought to find whether integrating a reform-based math curriculum with a traditional math curriculum affected fifth grade students’ ability to calculate area and perimeter. Student results of calculating perimeter and area, questions 5 and 6 of the unit pretest and posttest, were compared using mean scores and a paired sample $t$-test. Class pretest mean scores were $0.81$ ($SD = 1.11$) as compared to class posttest mean scores of $3.08$ ($SD = 1.01$). The paired sample $t$-test performed on calculating area and perimeter questions had a $t$-value of $-8.66$ with a two-tailed significance level of $0.001$. The difference between the means was statistically significant.

Using a paired samples $t$-test, the mean found was $-8.917$ in comparing Group 2 results of the ITBS subtest Concepts and Estimation. The NSS increased by approximately 8.9 points. Focusing on the one ITBS test item dealing with area, the Group 2 score decreased from $0.71$ ($SD = 0.464$) to $0.67$ ($SD = 0.482$). The paired samples $t$-test comparison of the same test item was found to be $0.042$ ($SD = 0.550$). Group 2 scores on the one ITBS item dealing with area decreased by $0.042$ points with a statistically
significant level of .714. The difference between the mean score was not a statistically significant change.

Results of the calculation of perimeter and area questions on the pretest and posttest of Group 3 were compared using total points scored. Group 3 member 1, Larry, scored 0 points out of a 4 possible points on the pretest and scored 1 point out of 4 possible points on the posttest. Group 3 member 2, Karen, scored 1 point out of 4 possible points on the pretest and scored 2 points out of 4 possible points on the posttest. Both Group 3 members increased their scores by 1 point on the posttest.

Both Group 3 members increased their NSS on the ITBS mathematics subtests from their fourth grade year to their fifth grade year. Larry’s total NSS score for both mathematics subtests increased from 178 to 189, and Karen’s NSS total score increased from 194 to 208. Group 3 members scored higher on open-ended perimeter and area knowledge pre and posttest questions than test questions that asked them to calculate area and perimeter. These open-ended questions asked students to explain their understanding of area and perimeter, given a drawing of an array, as compared to only calculating the perimeter and area given the dimensions of arrays in word form.

Student results of the problem-solving questions on the unit pretest and posttest were compared using mean scores and a paired samples t-test. Group 2 pretest mean scores were .17 (SD = .38) as compared to Group 2 posttest mean scores of 3.23 (SD = .98). The mean of the paired samples t-test was -3.06 (SD =1.16). The t-value of this paired samples t-test was -12.89 with a significance level of .001, t(23) = -12.89, p < .001. The mean score of Group 2 on questions 3 and 4 increased with a significance level
that was statistically significant. There was a statistically significant change in mean scores.

Results of the problem-solving questions on the pretest and posttest for Group 3 were compared using total points scored on these two questions. Group 3 member 1, Larry, scored 0 points out of a 4 possible points on the pretest and scored 3.5 points out of 4 possible points on the posttest. Group 3 member 2, Karen, scored 0 points out of 4 possible points on the pretest and scored 0 points out of 4 possible points on the posttest. Group 3 member 1 increased his score from pretest to post-test, as compared to Group 3 member 2, who showed no improvement in scores.

Larry’s total NSS score for the ITBS subtest Problem-Solving and Data Interpretation increased from 167 to 181 from his fourth grade year to his fifth grade year. This was an increase of 14 points. During the task-based interview Larry eventually gave up solving the problem and was unsuccessful in finding a solution.

Karen’s NSS subtest score on the Problem-Solving and Data Interpretation subtest increased 10 points from 191 to 201. Karen solved the problem presented to her during the task-based interview but showed no understanding of how she arrived at her solution or the relationship between area and perimeter.

Research Question 2

The second research question asked “What impact does mathematics instruction that implements reform-based problems within a traditionally taught classroom, have on struggling learner’s self-perception as a mathematical problem-solver?” Math attitude surveys (see Appendix B) were given before and after the unit of instruction on area and
perimeter. The math attitude survey was given to Group 1 before the unit of instruction by Mr. Halverson. The teacher read the instructions scripted by the researcher and read each descriptor aloud to the class. The same attitude survey was administered by the regular classroom teacher in the same manner after the unit implemented during this research study.

The researcher observed the administration of the attitude survey before the unit of instruction. The attitude survey given after the implementation of the area and perimeter unit was not observed by the researcher, but Mr. Halverson stated it was administered in the same manner as the preattitude survey.

**Group 2 Pretest Results of Math Attitude Survey**

All students in the research sample who completed the unit of study in the regular classroom were given a pre and post math attitude survey. The survey, originally developed by Dutton and Blum (1968) to establish self perception of students as mathematicians, was adapted to meet the needs of the age level of the research participants by the researcher. The math attitude survey consisted of 22 statements, read aloud by the classroom teacher to the students, followed by students marking agree or disagree. Dutton and Blum’s Attitude Survey has been modified in the past (Hong, 1996; Reyes, 1984) and used as a tool to measure math dispositions of students in the math classroom. The survey statements were clustered by the researcher into 3 categories: Cluster 1: confidence as a mathematician; Cluster 2: enjoyment of doing mathematics; and Cluster 3: appreciation of mathematics. The mean score for Cluster 1 was 6.46 ($SD = .93$) out of a total possible of 7. Cluster 2 had a mean score of 5.92 ($SD = 1.77$) out of ten
points possible and Cluster 3 had a mean score of 3.17 ($SD = 1.01$) out of 5 total points.

**Group 2 Posttest Results of Math Attitude Survey**

All 24 students in the sample completed the attitude survey at the completion of the unit of study. The classroom teacher stated he administered the post attitude survey in the same way as he administered the attitude survey prior to the unit of study on area and perimeter. Mr. Halverson read the directions aloud to the class and read each of the 22 descriptors aloud as students marked their responses. The mean scores of the post attitude survey Cluster 1 was 6.75 ($SD = .61$) out of a total possible 7. Cluster 2 and Cluster 3 had mean scores of 6.12 ($SD = 1.75$) out of a total possible ten and 2.95 ($SD = .91$) out of a total possible 5, respectively. Table 15 lists descriptive statistics of pre and post attitude survey results of the research sample.

In comparing Cluster 1: confidence in problem solving, there was an increase in the mean score from 6.46 to 6.75, a change of 0.29. An increase of approximately 0.21 occurred in Cluster 2, enjoyment of solving mathematics problems. The mean scores in Cluster 2 increased from 5.92 to 6.13. When students were surveyed about their appreciation of mathematics, Cluster 3, there was a decrease in mean scores from 3.17 to 2.96, a change of -0.21.

**Group 2 Paired Sample Results of Attitude Survey Clusters**

A paired sample $t$-test was calculated using pre and post attitude survey results. Two of the five questions in Cluster 3 included two ideas within one question. This makes any conclusions of student responses difficult to interpret. A separate paired sample $t$-test was calculated using pre and post attitude survey results of the remaining
Cluster 3 questions, eliminating the two confusing survey items. Table 16 summarizes the results of the three clusters of questions from the attitude survey: confidence, enjoyment, and appreciation.

Overall, students did show an increase in their confidence as problem solvers in mathematics with a mean increase of .29 (SD = .69). Student enjoyment of solving mathematical problems also showed a mean increase of .21 (SD = 1.71). Cluster 1, confidence as mathematics problem solver, resulted in a t-value of -2.070 with a significance level of .050, t(23) = -2.070, p < .050. Cluster 2, enjoyment of mathematical problems, resulted in a t-value of -5.94 with a significance level of .558, t(23) = -5.94, p < .558. The difference between means in Cluster 1 showed a statistically significant difference. The effect size of this difference was .37. The difference between means in Cluster 2 did not show a statistically significant difference. Cluster 3, appreciation of mathematics, showed a mean decrease of -0.21 (SD = 1.14) with a significance level of .38 and a t-value of .894, t(23) = .894, p < .38. There was not a statistically significant difference in means in Cluster 3.

Two of the five questions in Cluster 3 included two ideas within one question. This makes any conclusions made from student responses difficult to interpret. A paired sample t-test was calculated using pre and posttest results of the remaining Cluster 3 questions, eliminating two confusing survey items. The mean difference was .375 (SD = .88) with a significance level of .047 and a t-value of 2.099, t(23) = 2.099, p < .047. The paired samples t-test of the three questions of Cluster 3 showed a decrease in appreciation of mathematics and was statistically significant. These results are included in Table 17.
Students showed an increase in their confidence as problem solvers and an increase in their enjoyment of mathematics. The increase in confidence as problem solvers was shown statistically significant as an outcome of the implementation of the unit of instruction. The increase of enjoyment of mathematics was not statistically significant. There was a decrease in appreciation of mathematics that was statistically significant.

Table 16

*Attitude Survey Pre and Post Results*

<table>
<thead>
<tr>
<th>Cluster 1: Confidence as mathematics problem solver.</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest Results</td>
<td>24</td>
<td>6.46</td>
<td>.93</td>
</tr>
<tr>
<td>Cluster 2: Enjoyment of solving mathematical problems.</td>
<td>24</td>
<td>5.92</td>
<td>1.77</td>
</tr>
<tr>
<td>Cluster 3: Appreciation of mathematics.</td>
<td>24</td>
<td>3.17</td>
<td>1.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 1: Confidence as mathematics problem solver.</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Attitude Results</td>
<td>24</td>
<td>6.75</td>
<td>.61</td>
</tr>
<tr>
<td>Cluster 2: Enjoyment of solving mathematical problems.</td>
<td>24</td>
<td>6.12</td>
<td>1.75</td>
</tr>
<tr>
<td>Cluster 3: Appreciation of mathematics.</td>
<td>24</td>
<td>2.95</td>
<td>.91</td>
</tr>
</tbody>
</table>
Group 3 Members

The students making up Group 3 of this study were two fifth grade students who struggle learning mathematics. Students who struggle to learn mathematics were defined for the research study as scoring below the 40th Iowa percentile rank on the Iowa Test of Basic Skills in the mathematics subtests. Larry (male) and Karen (female) make up Group 3. Neither of the students receives additional mathematics instruction or support outside the regular math class from a special education teacher during the school year prior to or the school year during this research study.

Table 17

Paired Sample Results for Preadtitude and Post Attitude Survey

<table>
<thead>
<tr>
<th>Cluster</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>Sig.(Two-Tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1:</td>
<td>-0.29</td>
<td>0.69</td>
<td>-2.07</td>
<td>0.050*</td>
</tr>
<tr>
<td>Confidence as mathematics problem solver.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 2:</td>
<td>-0.21</td>
<td>1.71</td>
<td>-0.594</td>
<td>0.558</td>
</tr>
<tr>
<td>Enjoyment of solving mathematical problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 3:</td>
<td>0.21</td>
<td>1.14</td>
<td>0.894</td>
<td>0.380</td>
</tr>
<tr>
<td>Appreciation of mathematics (5 survey items.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 3:</td>
<td>0.375</td>
<td>0.875</td>
<td>2.099</td>
<td>0.047*</td>
</tr>
<tr>
<td>Appreciation of mathematics (3 survey items).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*= statistically significant
Group 3 Member 1: Larry

Larry showed few changes in his attitude towards mathematics according to the pre and post attitude survey given for this study. Larry changed his response to 4 of the 22 items on the attitude survey. Overall, Larry’s changes in response to survey items showed he grew more tired of math but increased his appreciation of math. One item showing a change in response was in Cluster 2, enjoyment of mathematics problem-solving. This item showed Larry agreeing with the statement: “I never get tired of working with numbers,” on the preattitude survey, then disagreeing on the post attitude survey. The other three changes in responses of Larry’s attitude survey results were in Cluster 3, appreciation of mathematics. On the preattitude survey Larry agreed with item 4, “I like math because it is practical,” and disagreed with this statement on the post attitude survey. Item 5, “I don’t think math is fun, but I always want to do well in it,” was a statement Larry agreed with on the preattitude survey and disagreed with on the post attitude survey. Item 5 was one of the items on the attitude survey questioned by the researcher because of the way it was written. Larry disagreed with item 8 on the preattitude survey, “math is something you have to do even though it is not enjoyable” but agreed with this statement on the post. The Table 18 shows the changes in Larry’s attitude survey results.

Group 3 Member 2: Karen

Karen, focus group member 2, showed a change in attitude on seven of the items given on the attitude survey. Each cluster resulted in changes of two or three items. Overall, Karen’s change in responses showed an increase in confidence as a problem
solver as well as an increase of enjoying mathematics and appreciating mathematics. In Cluster 1, confidence as a problem solver of mathematics, Karen changed her response on items 15 and 18 of the attitude survey. Both of these items resulted in Karen agreeing with statements that included being “afraid of word problems” and “avoiding math” on the preattitude survey and disagreeing with these statements on the post attitude survey and disagreeing with these statements on the post attitude survey. Karen changed her responses on three items of Cluster 2, enjoyment of math problem-solving.

Table 18

*Attitude Survey Responses for Group 3 Member 1: Larry*

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Preattitude Response</th>
<th>Post Attitude Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. I never get tired of working with numbers.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>Cluster 3:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I like math because it is practical.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>5. I don’t think math is fun, but I always want to do well in it.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>8. Math is something you have to do even though it is not enjoyable.</td>
<td>Disagree</td>
<td>Agree</td>
</tr>
</tbody>
</table>

Karen changed her response from disagree to agree on statements given on the attitude survey which included “math thrills me, and I like it better than any other subject” and “I never get tired of working with numbers.” Karen’s response to a third item in Cluster 2,
"I think math is the most enjoyable subject I have ever taken," changed from disagree on the preattitude survey to agree on the post attitude survey. Cluster 3 focused on appreciation of mathematics and results showed Karen changing her responses on two survey items. On both items in this cluster Karen agreed with the statements on the preattitude survey including phrases “I don’t think math is fun” and “I am not enthusiastic about math, but have no dislike for it either.” Karen disagreed with these statements on the post attitude survey. Both of these survey items in Cluster 3 were eliminated by the researcher because of the way the item was written. The Table 19 shows Karen’s changes in attitude survey items.

Summary for Question 2

An attitude survey given before the implemented unit of instruction and immediately following the completion of the unit of was used to answer this research question. The attitude survey of 22 items was broken into three clusters: confidence as a problem solver of mathematics, enjoyment of mathematics problem-solving, and appreciation of mathematics. These clusters were compared using a paired sample t-test. Paired sample mean of Cluster 1 was -.29 ($SD = .69$) with a significance level of .05. Paired sample mean of Cluster 2 were -.21 ($SD = 1.71$) and a significance level of .558. Cluster 3 resulted in a paired sample mean of .21 ($SD = 1.14$) and a significance level of .380. In summary, students showed an increase in their confidence as problem solvers, and it was statistically significant. There was increase in their enjoyment of mathematics, but it was not statistically significant. There was a decrease in the level of appreciation of mathematics in Group 2 which was statistically significant.
Table 19

*Attitude Survey Responses for Group 3, Member 2: Karen*

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Preattitude Response</th>
<th>Post Attitude Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cluster 1: Confidence as problem solver of mathematics.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. I avoid math because I am not very good with numbers.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>18. I am afraid of doing word problems in math class.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td><strong>Cluster 2: Enjoyment of mathematics problem-solving.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Math thrills me, and I like it better than any other subject.</td>
<td>Disagree</td>
<td>Agree</td>
</tr>
<tr>
<td>17. I never get tired of working with numbers.</td>
<td>Disagree</td>
<td>Agree</td>
</tr>
<tr>
<td>21. I think math is the most enjoyable subject I have ever taken.</td>
<td>Disagree</td>
<td>Agree</td>
</tr>
<tr>
<td><strong>Cluster 3: Appreciation of mathematics.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I don't think math is fun, but I always want to do well in it.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
<tr>
<td>6. I am not enthusiastic about math, but I have no real dislike for it either.</td>
<td>Agree</td>
<td>Disagree</td>
</tr>
</tbody>
</table>
Group 3 members showed changes in responses to survey items before and after the implemented unit of instruction for this research study. Group 3 member 2, Karen, showed changes in responses to two items in Cluster 1, confidence in mathematics problem-solving, changes in three items in Cluster 2, enjoyment of mathematics, and changes in two items in Cluster 3, appreciation of mathematics. Group 3 member 1, Larry, showed no changes in responses to items in Cluster 1 dealing with confidence in mathematics problem-solving. Larry did show a change in response to one item in Cluster 2 focusing on enjoyment of mathematics and two items in Cluster 3 dealing with appreciation of mathematics.

Research Question 3

The third research question asked, "What impact does the teacher's classroom structure when utilizing reform-based problems, have on struggling learners' understanding of perimeter and area?" The conceptual ideas associated with research question three included: (a) the teaching of mathematics for struggling learners in authentic and meaningful contexts, (directly modeling problem-solving strategies, sequencing instruction, and giving students opportunities to communicate their mathematical understanding; Sherman et al., 2009), and (b) increased conceptual understanding of mathematics improves student self-perception as a mathematics problem solver (Allsopp et al., 2003).

The classroom teacher in this research study developed a routine in the math class which was consistent whether using a reform-based problem or a traditional lesson. Students were familiar with the structure of the class and knew what was expected on a
daily basis. Whether the teacher focused on student discovery using a reform-based problem or a traditional curriculum problem, effective instruction occurred when the structure of the classroom was consistent. The classroom teacher allowed students to experience mathematics lessons that introduced a problem, allowed them to explore and to discover the mathematical concept, and discussed and established the important outcomes of the problem. Mr. Halverson consistently developed lessons incorporating these characteristics of reform-based curriculum and instruction. The structure of the classroom in this research study allowed students time to discuss the mathematics being explored. Students were given ample time to work on mathematical problems in small groups discussing and explaining their thoughts and ideas.

A large group discussion facilitated by the regular classroom teacher drawing out key points of understanding also occurred at the conclusion of each problem. These discussions allowed students time to clarify their thinking and understanding of area and perimeter concepts. During large group discussions and small group work, Mr. Halverson often used clarifying questions to help students solidify their understanding or discover their own misconceptions. All 10 lessons observed by the researcher had students reviewing the previous one or more days’ learning through whole class discussion, and then presenting students with the next task or skill to be completed. Presenting students with problems similar to the previous days’ learning reinforced the concept being studied.

The structure of the mathematics classroom in this research study seemed to benefit struggling learners of mathematics. Both members of Group 3 increased scores on unit posttest assessments when asked to calculate area and perimeter given in open-ended
questions and when answering questions applying area and perimeter concepts. Larry, Group 3 member 1, increased his score on open-ended questions from 0 points on the pretest to 9 out of 10 points on the posttest. Karen, Group 3 member 2, increased her score on open-ended questions from 5 points on the pretest to 10 out of 10 points on the posttest.

From the attitude survey implemented Group 3 member 1, Larry, showed a slight increase in enjoyment of solving mathematics problems and appreciation of mathematics. Group 3 member 2, Karen, showed an increase in confidence solving mathematics problems and an appreciation of mathematics. Group 3 members did not increase their class participation in large group discussions, but were observed more frequently becoming actively involved in discussing solutions to problems during small group discussions.

Mr. Halverson was not observed in any of the 10 classroom observations calling on Group 3 members during large group discussions. Group 3 member 2, Karen, did volunteer three times during large group discussions observed. Mr. Halverson was observed individually discussing ideas and student thinking with Group 3 members during small group work and individual work time.

Summary for Question 3

The third research question attempted to answer the question, “What impact does the teacher’s classroom structure when utilizing reform-based problems have on struggling learners’ understanding of perimeter and area?” The classroom teacher in this research study consistently developed a classroom routine whether teaching a traditional
Struggling learners of mathematics benefited from the consistent structure in the classroom evident from increased scores on unit posttest assessments and changes in self-perception as problem solvers of mathematics and appreciation of mathematics.

**Conclusions**

Based on the observations and results of the statistical findings during this case study, the following conclusions were drawn.

1. It appeared that student accuracy when calculating area and perimeter increased after the implemented unit of instruction. Based on the results of the calculating perimeter and area questions on the pretest and posttests, there was a significant difference. These differences were significant at $p < .0001$ level for the combined class results (Group 2) of the paired sample $t$-test on the calculating area and perimeter questions. Data collected and analyzed with a paired sample $t$-test on one item of the Iowa Test of Basic Skills math subtest Concepts and Estimation, testing area calculation, showed a statistically significance difference. This difference was significant at the $p < .001$ level. Students showed an improvement in accuracy when calculating area and perimeter problems after the implementation of problem-based activities within a traditionally taught classroom.

2. Students in Group 3, those identified as struggling learners of mathematics, gave accurate solutions when calculating area on the pretest and posttest implemented during the research study. The two students in Group 3 gave incorrect answers for the perimeter of the array. Students in Group 3 did show improvement in accurately
calculating area but did not have a comparable increase in points scored as students in Group 2.

3. Students in Group 3 performed better on calculating area and perimeter on the pretest and posttest items when given the dimensions of the arrays as number symbols, rather than numbers in word form. Both students in Group 3 incorrectly answered perimeter questions when given dimensions as words.

4. Group 3 results for questions 3 and 4 on the pretests and posttests were compared using total points scored. Larry, Group 3 member 1, increased his score from 0 points out of 4 possible points on the pretest to 3.5 points out of 4 possible points on the posttest. Karen, Group 3 member 2, did not increase the total number of points she scored. Karen scored 0 out of 4 points possible on the pretest and the posttest. Larry and Karen showed different outcomes on results for questions 3 and 4 dealing with applying area and perimeter concepts in a problem-solving situation. The similarities in improved scores of accurately calculating area and perimeter were not evident in the application problems of area and perimeter.

5. A significant difference occurred in the data for Cluster 1, confidence as a mathematics problem solver, after implementing a pre and post attitude survey to fifth grade students during the course of the research study. The differences were statistically significant at \( p < .05 \) for the combined class results of the paired sample \( t \)-test calculated on survey responses. Data show students displayed an increase in confidence when solving math problems but indicated a decrease in their enjoyment and appreciation of mathematics.
6. From the classroom observations of instruction, it was evident to the researcher that the classroom teacher gave specific and consistent expectations about the structure of math class, student behavior, math journal requirements, small group work, and large class discussion. During 10 of the classes observed, the teacher reminded students of these expectations and gave respectful verbal cues to acknowledge appropriate student behavior and completed work. A structured classroom was achieved when implementing problem-based activities within a traditional atmosphere.

Summary of Results

Problem-based activities and lessons dealing with the concepts of area and perimeter were integrated within a traditionally taught fifth grade mathematics class. The regular classroom teacher instructed all lessons and activities. All members of Group 2 participated in the implemented unit's lessons and activities, the pretest and posttest, standardized testing, as well as the pre and post attitude survey. Students in Group 3 were chosen based on their previous mathematics scores on the ITBS mathematics subtests and therefore identified as struggling learners in mathematics. The researcher implemented a task-based interview with the two members of Group 3. Data from several sources were reviewed by the researcher: unit pretests and posttests, attitude surveys (before and after), ITBS scores, in-class observations, videos of classroom instruction, and task-based interviews of Group 3 members.

Scores of the pretest and posttest, along with ITBS results, and task-based interviews were used to answer research question one. When comparing pretest and posttest questions 5 and 6 using a paired sample t-test a mean score of -2.27 (SD = 1.29)
was found. The $t$-value was approximately -8.66 with a two-tailed significance level of .001. The majority of students showed a statistically significant improvement in accuracy in computing area and perimeter from the time of pretest to the time of posttest. The two students of Group 3 showed an increase in scores on questions 5 and 6 of the pre and posttest given. Mean results of the fourth grade and fifth grade NSS of the Concepts and Estimation subtests were compared using a paired sample $t$-test. The mean score was -8.92 ($SD = 16.04$). There was an average increase of approximately 9 points on students’ NSS scores of the ITBS Concepts and Estimation subtest. The difference between the mean score was not a statistically significant change. The two students making up Group 3 showed an increase in scores on questions 5 and 6 of the pre and posttests given and an increase in NSS scores of the Concept and Estimation subtest of the ITBS. Questions 3 and 4 of the pretest and posttest were analyzed using a paired samples $t$-test. The mean of the paired samples $t$-test was -3.06 ($SD = 1.16$). The $t$-value of this paired samples $t$-test was -12.89 with a significance level of .001. There was a statistically significant change in mean scores. Group 3 member 1 increased his score from pretest to posttest, as compared to Group 3 member 2, who showed no improvement in scores.

To answer the second research question measuring change in attitude towards mathematics, an attitude survey was used. Students showed an increase in their confidence as problem solvers, and it was statistically significant. There was increase in their enjoyment of mathematics, but it was not statistically significant. There was a decrease in the level of appreciation of mathematics in Group 2 which was a statistically significant difference.
The third research question attempted to answer the question, "What impact does the teacher's classroom structure when utilizing reform-based problems, have on struggling learners' understanding of perimeter and area?" The classroom teacher in this research study consistently developed a classroom routine whether teaching a traditional mathematics lesson or teaching a reform-based mathematics activity. Struggling learners of mathematics benefited from the consistent structure in the classroom evident from increased scores on unit posttest assessments and changes in self-perception as problem solvers of mathematics and appreciation of mathematics.
CHAPTER 5

SUMMARY, FINDINGS, RECOMMENDATIONS, AND REFLECTION

This descriptive case study explored the impact of mathematics instruction that integrates reform-based problems within a traditionally taught classroom on the struggling learner’s understanding of area and perimeter and their self-perception as a mathematical problem-solver. This study also examined the impact on the struggling learner’s understanding of mathematics, when teachers structure mathematics lessons around reform-based problems. It was the researcher’s goal to develop a better understanding of the use of reform-based problems and curriculum utilized in the regular mathematics classroom that is effective for struggling learners of mathematics.

The unit implemented during the course of this study addressed the mathematical concepts of area and perimeter in a fifth grade classroom. The implemented unit was designed by the researcher with input from the regular classroom teacher concerning curriculum used in the past when studying area and perimeter concepts. For this study, struggling learners of mathematics were defined as students scoring below the 40th percentile on the mathematics subtests of the Iowa Test of Basic Skills. The regular fifth grade mathematics teacher taught the area and perimeter unit, and the researcher collected data from students using multiple methods: pretest and posttests, task-based interviews, attitude surveys, classroom observations and standardized test scores.

Because of the small number of participants, the researcher was able to examine and describe members of Group 3, struggling learners of mathematics, and identify themes consistent throughout the research project. This descriptive case study presented
qualitative and quantitative data sources in an attempt to answer the following research questions:

**Research Questions**

1. What impact does mathematics instruction that integrated reform-based problems within a traditionally taught classroom, have on a struggling learner’s understanding of area and perimeter?

2. What impact does mathematics instruction that integrates reform-based problems within a traditionally taught classroom, have on a struggling learner’s self-perception as a mathematical problem-solver?

3. What impact does the teacher’s structure of the classroom when utilizing reform-based problems, have on struggling learner’s understanding of area and perimeter?

**Delimitations of Study**

Struggling learners of mathematics based on standardized test scores was the focus of this study. First, students identified as the subject of this case study were selected based on their prior scores on the mathematics subtests of the Iowa Test of Basic Skills. Two students were observed and interviewed who scored below the 40th percentile on the Mathematical Concepts and Estimation Subtest and the Mathematical Problem-Solving and Data Interpretation Subtest of the ITBS tests. The 40th percentile was selected as the guideline since it has been established by the Iowa Department of Education and No Child Left Behind Legislation as the minimal level of student
proficiency in mathematical achievement (No Child Left Behind Procedures, Guidelines, and Policy, 2006).

This descriptive case study focused on the identified students’ overall understanding of the concepts of area and perimeter. The factors that were not accessible to the researcher were not taken into consideration when analyzing the study’s data. These factors included previous style of mathematical instruction, students’ time spent in the district, and personal factors of the students’ home life. The study focused on only data established by pretest and posttests, task-based interviews, attitude surveys, and standardized test scores of selected participants outlined in Chapter 3, The Methodology, of this research study.

Limitations

The first limitation of this study related to the size and selection of the sample. The population of this descriptive case study was made up of 26 fifth grade students. Access to and familiarity with the school district makes the selection of this classroom suitable for this descriptive case study. The results of the study were limited to a similar classroom setting with similar student population.

A second limitation of the study is the researcher’s lack of first-hand knowledge of the classroom teacher’s teaching style and the routines that the teacher uses to establish a classroom environment that encourages risk taking. However, in the researcher’s role as a supervisor of pre-service teachers in field experiences, the researcher has placed several students in the selected teacher’s classroom. These pre-service teachers have conveyed information to the researcher about their classroom experiences with this teacher during
the 2008-2009 and the 2009-2010 school years and have discussed the atmosphere of respect established in this teacher’s classroom. Video tapes of the classroom instruction viewed by the researcher gave additional insight into the teacher’s teaching style and established classroom routines. The researcher’s initial contacts with this teacher established the fact that this teacher has little experience or training implementing reform-based problems in the mathematics classroom.

A third limitation of this research study is that it is a descriptive case study, which by nature is unique to the case. Therefore, it is unlikely that the findings are generalizable to other classes. However, the purpose of the study was to gain insight to struggling learners of mathematics thinking and learning when reform-based problems and classroom structure were utilized. The results of this study may be helpful to those who choose to implement reform-based problems within a traditionally taught mathematics classroom.

**Summary of Research Questions**

A brief summary of the research questions and resulting data will be given in the following sections.

**Research Question 1**

Research question 1 focused on struggling learner’s understanding of area and perimeter concepts. This research question examined the struggling learner’s ability to calculate area and perimeter problems along with applying the concepts in problem-solving situations. The two students identified as struggling learners of mathematics, Group 3, showed an increase in total points scored on questions asking students to
compute the area and perimeter of arrays on the unit pretest and posttests. Students in Group 3 scored more total points on open-ended questions dealing with area and perimeter and the calculations than questions giving array dimensions in written words. Mean results of the fourth grade and fifth grade NSS of the Concepts and Estimation subtests were compared using a paired sample t-test. The mean score was -8.92 (SD = 16.04). There was an average increase of approximately 9 points on students’ NSS scores of the ITBS Concepts and Estimation subtest. The difference was not a statistically significant change. Both Group 3 members increase their NSS scores on the Concept and Estimation subtest of the ITBS. Comparing Group 3 NSS scores on the ITBS Reading subtest found member 1 increasing his score, whereas member 2’s score decreased.

Questions 3 and 4 of the pretest and posttest focused on application of area and perimeter concepts in a problem-solving context. A paired sample t-test was use to analyze the results of questions three and four on the pretest and the posttest. There was a statistically significant change in mean scores for Group 2. The mean of the paired sample t-test was -3.06 (SD = 1.16). The t-value of this paired sample t-test was -12.89 with a significance level of .001. Students in Group 2 increased their scores on questions involving application of area and perimeter concepts in a problem-solving context. Group 3 member 1 increased his score from pretest to posttest, as compared to Group 3 member 2, who showed no improvement in scores on the problem-solving questions of the pretest and posttest. Both Group 3 members showed an increase in NSS scores on the ITBS mathematics subtest of Problem Solving and Data Interpretation.
Research Question 2

The second research questions focused on the impact of reform-based problems within a traditionally taught classroom and the struggling learner’s self-perception as a mathematical problem-solver. To measure student change in attitude towards mathematics, an attitude survey was used. Students in Group 2 showed a statistically significant increase in their confidence as problem solvers. There was an increase in their enjoyment of mathematics, but it was not statistically significant. There was a decrease in the level of appreciation of mathematics in Group 2 which was statistically significant. Overall, students in Group 2 showed an increase in confidence as mathematical problem-solvers but did not increase their appreciation and enjoyment of mathematics. Group 3 member 1 showed three changes in survey responses from Cluster 3: Appreciation of Mathematics. Member 1 gave adjusted responses to the post attitude survey indicating his appreciation for mathematics grew, even though he disliked doing mathematics problems. Group 3 member 2 showed two or three changes in survey responses in each cluster of the attitude survey. Member 2 gave adjusted responses to the post attitude survey indicating a growth in her confidence as a mathematical problem solver and her enjoyment of mathematical problem-solving. The two items from the Appreciation of Mathematics Cluster on the post attitude survey Group 3 member 2 changed were the two items eliminated by the researcher because of the unclear nature of these survey items. This makes any conclusion about a change in member 2’s appreciation of mathematics difficult to establish.
Research Question 3

The third research question exploring what impact the teacher's classroom structure when utilizing reform-based problems, has on the struggling learner's understanding of area and perimeter was answered through observations of classroom instruction and Group 3 results of pretest and posttests given during the research study. The two members of Group 3 both showed an increase in understanding the mathematical concepts of area and perimeter when classroom instruction was consistent and student expectations were clear and given daily. The classroom teacher consistently instructed mathematics lessons similarly whether implementing a reform-based problem or using a traditional lesson. The ten class sessions viewed by the researcher were consistently divided into a warm-up practicing mathematical skills, a large group discussion or presentation of solutions, and a time to explore a problem in small groups or individual work time. Both members of Group 3 showed an improved understanding of area and perimeter concepts by increased scores when calculating area and perimeter or when applying these concepts to contextual problem-solving situations, or increases of scores in both areas.

Findings

Two findings of this descriptive case study include (a) the increase in points scored when students struggling to learn mathematics were given array dimensions in numerals rather than words; and (b) students struggling to learn mathematics experienced success when given problem-solving situations in a traditionally structured mathematics classroom. The first finding was established through outcomes of research question 1
which explored student accuracy in calculating area and perimeter. The second finding was established through outcomes of research questions 1, 2, and 3 along with classroom observations made by the researcher.

**Finding 1: Reading Comprehension Connections to Mathematical Understanding**

The two students making up Group 3 showed a decrease in scores on problems asking them to calculate perimeter as compared to Group 2’s average increase in scores on similar problems. The two members of Group 3 also scored fewer points on area and perimeter problems when the dimensions were given in words rather than numerals. When members of Group 3 were presented with an array with its dimensions given as numerals, both students gave accurate answers in calculating area and perimeter.

A common struggle for students is not having the ability to easily translate a written sentence in mathematics to a number sentence (Allsopp et al., 2003). Little understanding of mathematics vocabulary and limited ability to read problems lead to early frustration and in turn low achievement (Allsopp et al., 2003; Clements, 2003; Sherman et al., 2009). Classroom teachers wishing to improve success in mathematical understanding for struggling learners need to continue to explore and implement effective reading strategies within mathematical instruction. According to Marzano, Pickering, and Pollock (2001), the following generalizations can be used to guide instruction of vocabulary terms in the mathematics classroom:

1. Students must encounter words in context more than once to learn them.
2. Instruction in new words enhances learning those words in context.
3. One of the best ways to learn a new word is to associate an image with it.
Finding 2: Problem-Solving in a Structured Classroom

The two members of Group 3, identified as struggling learners of mathematics, both showed an increase in understanding of area and perimeter concepts when classroom instruction was structured around reform-based problems and student expectations were clear and consistent. Modifying the classroom structure typical to explicit teaching, to implement a reform-based problem helped meet the needs of those students struggling to learn mathematics. The context of reform-based problems and the constructivist instructional approach often implemented with these types of problems seems to motivate students (Kroesbergen et al., 2002). This research study supports the idea that though students may be motivated when instruction using reform-based problems are adapted to meet the needs of the struggling mathematics learner. The classroom teacher in this research study developed a routine in the math class which was consistent whether using a reform-based problem or a traditional lesson. Students were familiar with the structure of the class and knew what was expected on a daily basis. Whether the teacher focused on student discovery using a reform-based problem or a traditional curriculum problem,
effective instruction occurred when the structure of the classroom was consistent. The classroom teacher allowed students to experience a mathematics lesson that introduced a problem, allowed them to explore and to discover the mathematical concept, and discussed and established the important outcomes of the problem. The structure of the classroom in this research study allowed students time to discuss the mathematics being explored. Students were given ample time to work on mathematical problems in small groups discussing and explaining their thoughts and ideas. A large group discussion facilitated by the regular classroom teacher drawing out key points of understanding also occurred at the conclusion of each problem. These discussions allowed students time to clarify their thinking and understanding of area and perimeter concepts. In reform-based mathematics and explicit teaching, questioning and discussion are vital parts of the instructional process (Hudson et al., 2006; Larson, 2002; NCTM, 2000). These aspects of the teacher's classroom of this research study are similar in characteristics of reform-based problems but were implemented much like a traditional classroom setting.

There is increasing evidence that effective instruction is a key factor to helping students understand mathematics. According to Larson (2002), there are five essential characteristics of mathematics instruction used by effective mathematics teachers, and several ways to implement these five characteristics depending on the needs of the students, the objectives being taught, available resources, and teacher preference. These five characteristics include: introduction, development of concept or skill, guided practice, summary, and independent practice. The application of explicit teaching to a reform-based approach to mathematics which benefits low ability students is possible
when guiding principles for planning and delivering math instruction are followed (Copes & Shager, 2003).

**Recommendations**

Based on the findings of this qualitative descriptive case study the researcher has suggestions for the regular classroom teacher of mathematics, instructors of mathematics education programs for preservice teachers, instructors of in-service training programs for mathematics teachers, and researchers of mathematical education.

**Recommendations for Mathematics Education Programs**

It is necessary for the regular classroom teacher to be able to consistently construct lessons that have the characteristics to create successful learning experiences: introduction of a problem, time to explore and develop understanding, and group discussion. The classroom teacher in this research study created a classroom routine involving components of the traditional mathematics classroom along with key characteristics of reform-based instruction. Mathematics education programs must implement training of preservice educators focusing on designing mathematics lesson with specific learning goals in mind and presented in a structured way allowing all ability levels to reach a higher level of understanding. The training of preservice teachers should emphasize that mathematics instruction associated with a traditional teaching approach is possible to obtain when using problem-solving situations during mathematics instruction.

The teacher’s ability to facilitate a discussion after students had time to explore a mathematical problem was a component of consistent instruction which guided student understanding during this research study. The classroom teacher used open-ended
questions which allowed him to extract key understandings from students to build further conceptual understandings and correct student misconceptions. Mathematics education programs of preservice teachers should include training allowing preservice teachers to develop skills in decision making processes as when to provide students with information, what types of questions to ask, when to model a problem, and when to let students struggle with difficulties.

Another consideration for mathematics education programs of preservice teachers is field experience placements. Time spent in the classroom observing as a preservice teacher is valuable and impacts the preservice teachers' perception of effective instruction. Field experience placements should be examined carefully allowing preservice educators opportunities to observe and work with well-trained and effective in-service teachers.

Recommendations for School District Administration and Professional Development Consultants

Consultants of professional development and in-service training of mathematics educators need to work with public school administrators to implement effective and ongoing programs that support mathematics educators in utilizing effective reading strategies within the mathematics class and implementing problem-solving curriculum in a structured atmosphere. The data collected during the course of this research study demonstrates student success supporting implementation of problem-solving situations within a traditionally taught mathematics classroom. There is a growing area of research that encourages the teaching of mathematics for struggling learners in authentic and meaningful contexts, the direct modeling of problem-solving strategies, the sequencing of
instruction, and the giving to students opportunities to communicate their mathematical understanding (Allsopp et al., 2003). Teachers need effective programs of instruction to learn classroom pedagogies that reach the struggling learners of mathematics. The in-service program implemented must support mathematics teachers with release time and financial resources to make the necessary improvements in mathematics instruction, thus improving student achievement in mathematics.

Recommendations for Further Research

1. Further research might be completed to include a larger sample size involving a control group to determine the effects of problem-based mathematics instruction within a traditionally taught classroom on struggling learner’s understanding of mathematics. This study was limited in sample size with one fifth grade classroom from one school district in Iowa.

2. Further study of implementing reform-based problems in a traditionally taught classroom is beneficial at the middle school level. This research study was limited to a fifth grade classroom.

3. Further research needs to continue studying the use of effective reading strategies within the mathematics classroom at all levels of learning. Results of the current research study’s findings relate to connections between reading comprehension and mathematical understanding.

4. Further study needs to be completed to continue to determine instructional strategies that work together to benefit the needs of struggling learners of mathematics. This study was limited to one fifth grade classroom and its classroom teacher. The
classroom teacher was able to develop structured lessons around reform-based open-ended problems leading to student understanding. Links between reform-based instruction and traditional instruction were demonstrated by the instructional planning and classroom format put in place by the classroom teacher.

5. The current study might be modified to include the classroom teacher’s perception of struggling learners’ confidence when given reform-based activities.

6. The current study might be modified to include the classroom teacher’s self-perception and professional growth as a mathematics instructor when using reform-based mathematics in the classroom.

**Researcher’s Reflection**

The researcher has attempted to draw a descriptive picture of the need for continued improvement in teaching strategies and implementation of reform-based problems in a traditional classroom setting when working with students who struggle to understand mathematics. The researcher’s background in training involves the study of reform-based instruction, making the researcher familiar with the benefits and constraints of such instruction.

Due to the large range of diversity among students receiving math instruction in the regular classroom in today’s school systems, it is important for teachers to take into consideration the differences in learning abilities when planning instruction. Planning for differences in students’ mathematical capabilities can involve making adaptations to explicit teaching strategies that include components of reform-based mathematics instruction. Integrating these two types of instruction takes careful planning on the part of
the classroom teacher. The combination of these two different, but effective teaching methodologies, has demonstrated potential to increase mathematical competence for students of all ability levels.

This particular descriptive case study adds to the literature on struggling learners of mathematics. Specifically, the potential of integrating reform-based problems within a traditional mathematics classroom for struggling learners of mathematics. The context of reform-based problems can be motivating to struggling learners of mathematics. When the classroom teacher structures the instructional time, students struggling in the mathematics class are given the support they need to be successful at understanding the mathematical concepts.

It is the researcher's hope that teachers, mathematics education researchers, administrators, and mathematics education consultants will continue to explore and refine integrating reform-based mathematics instruction with explicit mathematics instruction. Continued implementation of reading strategies within the mathematics classroom also is necessary to increase mathematical understanding. The link between reading comprehension and mathematical understanding is an area of growth that will increase student success in the mathematics classroom. Continued study of effective instructional strategies that meet the needs of all students will increase the likelihood of gains in students' understanding of mathematics.
REFERENCES

Allsopp, D., Lovin, L., Green, G., & Savage-Davis, E. (2003). Why students with special needs have difficulty learning mathematics and what teachers can do to help. Mathematics Teaching in the Middle School, 8(6), 308-314.


APPENDIX A

UNIT PRETEST AND POSTTEST
Area and Perimeter

1. Explain everything you know about the area and perimeter of the following array.

2. Explain everything you know about the area and perimeter of the following array.
Problems 3 and 4 give the perimeter and area of an array. Find the length and width of each array prove to me why you think your answer is the correct solution. You may use color tiles to help you find the answers to these problems. You may use color tiles to solve the problems. Each color tile is one square inch.

3. Find the length and width of an array that has a perimeter of 22 inches and an area of 20 square inches.

4. Find the length and width of an array that has an area of 18 square inches and a perimeter of 18 inches.
Problems 5 and 6 ask you to find the area and perimeter of an array when given the dimensions. Make sure you label your answers correctly.

5. Length: nine inches  
   Width: eleven inches

6. Length: twelve inches  
   Width: five inches
APPENDIX B

TEACHER SCRIPT AND STUDENT ATTITUDE SURVEY
Teacher’s Script for Attitude Survey

This survey has questions that will tell me how you feel about doing math problems. There is no right or wrong answer. Answer questions honestly telling me if you agree or disagree with each statement. You will not be graded on this survey. This survey will help me and Mrs. Pothast learn more about teaching math in better ways.
# 5th Grade Math Attitude Survey

Name _______________________

Please put an "X" in the agree or disagree column depending upon which expresses your true feelings.

<table>
<thead>
<tr>
<th></th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don't feel sure of myself in math.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy seeing how rapidly and accurately I can work math problems.</td>
<td></td>
<td></td>
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<tr>
<td>I like math, but I like other subjects just as well.</td>
<td></td>
<td></td>
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<tr>
<td>I like math because it is practical.</td>
<td></td>
<td></td>
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<tr>
<td>I don't think math is fun, but I always want to do well in it.</td>
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<tr>
<td>I am not enthusiastic about math, but I have no real dislike for it either.</td>
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<td></td>
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<tr>
<td>Math is an important as any other subject.</td>
<td></td>
<td></td>
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<tr>
<td>Math is something you have to do even though it is not enjoyable.</td>
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<tr>
<td>Agree</td>
<td>Disagree</td>
<td></td>
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<td>----------------------------------------------------------------------</td>
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<tr>
<td>Sometimes I enjoy the challenge presented by a math problem.</td>
<td></td>
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<tr>
<td>I have always been afraid math.</td>
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<tr>
<td>I would like to spend more time in school working on math.</td>
<td></td>
<td></td>
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<tr>
<td>I hate math and avoid using it at all times.</td>
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<td></td>
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<tr>
<td>I enjoy doing problems when I know how to work them out.</td>
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<tr>
<td>I avoid math because I am not very good with numbers.</td>
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<td></td>
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<tr>
<td>Math thrills me, and I like it better than any other subject.</td>
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<td></td>
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<tr>
<td>I never get tired of working with numbers.</td>
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<td></td>
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<tr>
<td>I am afraid of doing word problems in math class.</td>
<td></td>
<td></td>
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<tr>
<td>Math is very interesting.</td>
<td></td>
<td></td>
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<tr>
<td>I have never liked math.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I think math is the most enjoyable subject I have ever taken.</td>
<td></td>
<td></td>
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<tr>
<td>I think about math outside of school.</td>
<td></td>
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APPENDIX C

GROUP 3 TASK-BASED INTERVIEW
AND RESEARCHER SCRIPT
Researcher Script
Task-Based Interview

**Researcher**: I am going to give you a problem to solve. These are topics you have been learning about in math class.

If you don’t want to do this activity you don’t have to. Not doing this activity will not affect your math grade in anyway. If we start the activity and then you later decide you don’t want to do it, just tell me and we will quit working on the problems. Again, not finishing the activity will not hurt your math grade in anyway.

Do you want to continue and work on the problem?

*Student completes task.*

**Researcher**: I think you have worked very hard at solving this problem You have done a very nice job explaining to me what you were thinking as you solved the problem. Do you have any questions? Thank you for working on the problem for me. It has helped me gain information on how students learn about mathematics.
Task-Based Interview Problem

The Garden Problem

Bob, Cathy, and Jim are working together to make the garden plot below larger.

Bob says, "We will need to buy more fencing, because the area of the garden will increase, and our current fencing won't go all the way around."

Cathy disagrees. She says, "We won't need more fencing, because we can move the fencing we have into a different position and still make the area of the garden larger."

Jim disagrees with both Bob and Cathy. He says, "I know a way to make the garden larger and use less fencing."

Who do you think is right? Explain your reasoning.

You can use pattern tiles and sketches to help solve this problem.
APPENDIX D

PARTICIPATING SCHOOL DISTRICT
ADMINISTRATION CONSENT FORM
University of Northern Iowa

Superintendent of Schools
XXXXXXX Community School District
XXXXXXX
XXXXXXX, IA XXXXX

October 9, 2009

Dear Administrator:

The research project involving students from the xxxxxxxxxx School District will require me to collect and analyze Iowa Test of Basic Skills scores. I am requesting permission to gain access to student records that contain this information.

Any information obtained in connection with this research project that can be identified from the district will be kept confidential and only used in the procedures of this research project. Any student information included on schools records such as social security number, date of birth, medical history, will be kept confidential.

Please complete the form below allowing access to student data for the purpose of this research study.

Sincerely,

Jennifer Pothast

The xxxxxxxxxx Community School System grants permission to Jennifer Pothast, graduate student at the University of Northern Iowa, to conduct research on 5th grade students in the xxxxxxxxxx Elementary School. As part of this research project, the researcher will be allowed access to student records of the participants of the research study. This information is allowed to be part of the final research project.

(Administrator’s Signature)
APPENDIX E

PARENT CONSENT AND STUDENT ASSENT FORMS
November 9, 2009

Dear Parent:

My name is Jennifer Pothast and I am a graduate student from the Department of Curriculum and Instruction at the University of Northern Iowa. I would like to include your child, along with his or her classmates, in a research project on math problems. We do not anticipate any risk greater than normal life and your child may benefit from this research by learning more about their math ability. If your child takes part in this project, math class will involve extra problems and activities during the study of area and perimeter. This study will be approximately 3 weeks in length. These extra activities will be in addition to the regular math curriculum on this topic. This project will involve collecting data on pretests, posttests, Iowa Test of Basic Skills Math tests scores, video taping math class, and classroom observations. A small group of students (4 or 5) will be interviewed to collect additional information on students’ understanding of the topic being studied.

Your child’s participation in this project is completely voluntary. In addition to your permission your child will also be asked if he or she would like to take part in this project. Only those children who want to participate will do so, and any child may stop taking part at any time. The choice to participate or not will not impact your child’s grades or status at school. The information and data gained during this research will be kept strictly confidential and secure and will not become a part of your child’s school record.

The results of the study will be used for my dissertation in completing a doctorate degree. All data used for written research outcomes will not include children’s names, making the source of the information unknown. Pseudonyms will be substituted for the names of children who are interviewed.

In the space at the bottom of this letter, please indicate whether you do or do not want your child to participate in this project. Ask your child to bring one copy of this completed form to his or her teacher by October 21. The second copy included is to keep for your records. If you have any questions about this research project, please feel free to contact me or my advisor by mail, email or telephone.

Sincerely,

Jennifer Pothast
Student Assent Form

Student Name__________________________

School______________________________

Research Topic: Integrating Problem Solving Activities Dealing with Area and Perimeter into a Traditional 5th Grade Math Curriculum

Researcher: Jennifer Pothast

I am doing a study as a research project in gaining a doctorate of education degree from the University of Northern Iowa. A research project is a special way to find out about something. I want to find out how students learn math best and how students feel about themselves as mathematicians.

If you agree to be part of the project you will be asked to take a math attitude survey and work on several different problems and activities in math class when you are studying area and perimeter. You may also be asked to individually work on a problem about area and perimeter and I will ask you questions on how you solved this problem. If you are interviewed, I will write down what you say. The risks during the project are no greater than what you encounter in everyday life.

You won’t be graded on anything you do for this research study and the results will not affect your school grades. All you have to do is give your best effort when doing the problems and activities that you are given, and you will do fine.

If you decide to be in this study, some good things might happen to you. You may realize you are better at math than you thought. Hopefully, you will learn about the topics of area and perimeter and how they relate to things in your life at school and at home. I don’t know for sure that these things will happen. We might also find out things about teaching and learning math that will help other students some day.

When we are done with the study, I will write a report about what I found out. I won’t use your name in the report.

You don’t have to be in this study. You can say “no” and nothing bad will happen. If you say “yes” now, but want to stop later, that’s okay too. All you have to do is tell me you want to stop.

If you want to be a part of this research project, please sign your name.

I, __________________________, want to be in this research project.

Date __________________________

Researcher Signature __________________________
University of Northern Iowa
Standard Application for Human Participants Review

Note: Before completing application, investigators must consult guidance at: http://www.uni.edu/osp/research/index.htm Always check website to download current forms.

All items must be completed and the form must be typed or printed electronically. Submit 2 hard copies to the Human Participants Review Committee, Office of Sponsored Programs, 213 East Bartlett, mail code 0394

Title of proposal: Integrating Problem Solving Within Traditional Math Curriculum

Name of (PI) Principal Investigator(s): Jennifer Pothast

PI Status: ☐ Faculty ☐ Undergraduate Student ☒ Graduate Student ☐ Staff ☐ Non-UNI

Project Type: ☐ Faculty/Staff Research ☒ Thesis/Dissertation ☐ Other-specify: Curriculum & Instruction

PI Phone: 319-415-7375

PI Email: jennifer.pothast@wartburg.edu

PI Address or Mail Code: 31493 260th ST ShellRock, IA 50670

Faculty Advisor Name: Donna Schumacher-Douglas

Advisor Phone: 319-273-5880

Advisor Email: donna.schumacher@uni.edu

Source of Funding: Not Applicable

Project dates: Mid April Through Mid-May '09 (4 week period)

All key personnel and Advisor (if applicable) must be listed and must complete IRB training/certification in Human Participants Protections. Attach a copy of the certificate, if not already on file in the IRB office.

Principal Investigator: Jennifer Pothast

Co-Investigator(s):

Faculty Advisor: Donna Schumacher-Douglas

Other Key Personnel: Jean Schneider

Other Key Personnel: (name)

SIGNATURES: The undersigned acknowledge that: 1. this application represents an accurate and truthful description of the proposed research; 2. the research will be conducted in compliance with the recommendations of and only after approval has been received the UNI IRB. The PI is responsible for reporting any adverse events or problems to the IRB, for requesting prior IRB approval, and any changes in the approved protocol. Signed after approval.

Principal Investigator: Jennifer Pothast

February 23, 2009

Co-Investigator(s):

Schumacher-Douglas

February 23, 2009

Faculty Advisor (required for all student projects):

Jean Schneider

February 23, 2009
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Office Use Only: Protocol #
A. PURPOSE OF RESEARCH.

Explain 1) why this research is important and what the primary purposes are, 2) what question(s) or hypotheses this activity is designed to answer, and 3) whether and how the results will be used or disseminated to others.

1) The purpose of this study is to improve mathematic instruction of perimeter and area concepts in the upper elementary grades. The study will particularly focus on students that struggle to learn mathematics. Through this study I hope to develop a better understanding of problem-based curriculum integrated with direct instruction in the elementary classroom that is effective for all students. Developing a learning environment that facilitates learning for all ability levels of students requires curriculum that engages the learner (NCTM Principles & Standards 2000).

The National Council of Teachers of Mathematics reform encourages teachers to create a learning environment that fosters the development of each student’s mathematical power and to engage in ongoing analysis of teaching and learning (NCTM Principles & Standards, 2000). Research in the area of mathematics has become increasingly more important with a need to prove the effectiveness of standards-based curricula and the increased demand on teacher practices and curriculum implemented in the classroom by national and state levels of government (Woodward & Brown, 2006).

Mathematics educators need to consider the all the aspects that the students they are teaching bring with them to the classroom. Students’ socioeconomic levels and special needs must be taken into consideration to improve educational opportunities for all students, thus promoting mathematical literacy and equity (Kitchen, DePree, Celedon-Pattichis, and Brinkerhoff, 2007).

Understanding fundamental concepts and accurately computing algorithms lead to students becoming mathematically proficient (National Research Council, 2001).
mathematics classroom should be a place where interesting problems are regularly being explored by using a variety of methods to effectively solve the problem. Some students may need extra assistance to meet the high expectations of mathematics that is being envisioned. Students who are not native speakers of English may need special attention to participate in classroom discussions or assessment accommodations. Students with disability may require extra time to complete assignments or require a written assessment to be read orally to them. Students with difficulties learning mathematics may need additional tutoring or after-school programs to become competent in understanding essential mathematical concepts. Students with exceptional understanding of mathematics may need additional enrichment programs or alternate resources to challenge them. Schools must attempt to accommodate the special needs of some students without inhibiting the learning of others (NCTM Principles and Standards, 2000).
The areas of geometry and measurement are particular areas of mathematics in which students often lack a solid conceptual understanding. Several studies have shown that U.S. elementary and middle grade students do not have an adequate understanding of basic geometric concepts, or geometric reasoning and problem solving. Without the basic geometric understandings, many students are unprepared to study more sophisticated geometric concepts in high school (Clements and Battista, 1992).

Among the necessary geometric and measurement concepts of study are perimeter and area. Perimeter and area are important real-world concepts that students need to make sense of through exploration (Wiest, 2005). There is often a lack of conceptual understanding of area and perimeter among elementary and middle school students. Research findings state students commonly confuse area and perimeter and that many elementary and secondary students lack an adequate understanding of area and area measurement (Outhred and Mitchelmore, 2000; Zacharos, 2006). Area and perimeter should not be a source of confusion or frustration for students. This confusion can often be attributed to the teaching of formulas for both concepts rather than a conceptual understanding of the concepts (Van de Walle, 2007). The ability to connect the understanding of perimeter and area conceptually to the necessary processes is essential if students are to make sense of these two mathematical concepts (Moyer, 2008).

To create students that are successful in mathematics, the concepts of area and perimeter must be conceptually understood by all students. All ability level students should be proficient at solving real-world problems involving area and perimeter, concepts that are connected to other areas of mathematics such as scaling and similarity. Geometric and measurement concepts and
skills should be developed throughout the school year rather than treated as a separate unit of study (NCTM Principles and Standards, 2000).

Too often geometry, along with measurement, is viewed by teachers and students as a study of vocabulary. In many elementary and middle school classrooms than language of geometry has been the focus of the geometry curriculum (Lindquist and Clements, 2001). Geometry at all levels needs to be studied for a purpose, not to perform geometric tasks because the teacher has asked them to. National Council of Teachers of Mathematics geometry standard states that students should use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM Principles & Standards, 2000). Studying geometry should also be to analyze mathematical situations, which will help students learn more about other mathematical topics. Understanding the concepts of measurement helps students connect ideas within other areas of mathematics and between mathematics and other disciplines (NCTM Principles & Standards, 2000). The study of perimeter and area occur in both areas of mathematics and are often topics confusing to many students (Muir, 2006).

The vocabulary of geometry and measurement should grow naturally from the study and exploration of problems involving these concepts (Lindquist & Clements, 2001). Vocabulary is best learned by using it. Educators need to be aware that vocabulary can limit students’ understanding unless it is used correctly and with a wide range of examples to build rich understanding of concepts (Lindquist and Clements, 2001).

Investigating, making conjectures, and developing logical arguments to justify conclusions are important aspects of studying geometry and measurement (NCTM Principles & Standards). All aspects of these topics must be explored. Omitting expectations about spatial
orientation and location deprives students of a foundation for understanding everyday applications, such as giving and receiving directions and reading maps, and other mathematical topics, including visualizing two- and three-dimensional objects, using geometric models for numerical and algebraic relationships, working with coordinates, and graphing, and perimeter and area.

The study of geometry in grades 3-5 should involve thinking and doing. All students at this age need the opportunities to sort, build, draw, model, measure, and construct their own ideas about the geometric properties and relationships. At this same time they are learning to reason and to make, test, and justify conjectures about these relationships (Lindquist & Clements, 2001).

**Teacher’s Role in Geometry and Measurement Instruction**

The teacher’s role in the classroom when teaching geometry concepts is essential to making geometry vital in the classroom. The process standards developed by NCTM are a key to making the concepts understandable and attainable to all students. The process standards include problem solving, reasoning and proof, communication, connections, and representations (NCTM Principles & Standards, 2000). The teacher needs to provide opportunities for students to learn and use geometry and also to foster reasoning through geometry and measurement. It is important for these opportunities to build on students’ strengths and allow the student to grow in their understanding of mathematics (Lindquist & Clements, 2001). The teacher must establish the expectation that the class as a mathematical community is continually developing, testing, and applying conjectures about the mathematical relationships that are being studied.
Current teaching and curricular practices do not align with the recommendations of NCTM. They promote little learning and conceptual growth and leave students unprepared for future study of geometry, measurement and many additional mathematical topics that require geometric knowledge (Clements, 2003). Studying geometry and measurement offers students ways to interpret and make sense of their physical environment and can be used as a tool for studying other topics in mathematics and science but receives little attention (Clements, 2003).

Lack in Understanding of Perimeter and Area

Research indicates that students find it difficult to explain and illustrate perimeter and area, because the topics are learned only as sets of procedures (Van de Walle, 2007). The results of National Assessment of Educational Progress (NAEP) tests show there is not a good understanding of area and perimeter formulas among U.S. students. Only 19 percent of fourth-grade students were able to give the area of a carpet 9 feet long and 6 feet wide (Kenney & Kouba, 1997). When presented with a similar question, only 65 percent of eighth-graders were able to compute the correct answer. Poor student performances such as this are often because of confusion about the area and perimeter formulas. This confusion is largely due to an overemphasis in classroom instruction on formulas with very little conceptual background. Simply telling students what the necessary formulas is does not create long lasting learning (Van de Walle, 2007).
Many students use the perimeter and area formulas but do not accurately conceptualize the meaning of height and base in both two- and three-dimensional geometric figures. Students confuse the height of a shape when it is slanted and do not realize any side or flat surface of a figure can be identified as the base of the figure (Van de Walle, 2007). It is necessary for the students to realize the height meets the base perpendicularly.

Another aspect of confusion for students studying area measure in particular is establishing the understanding that area requires identical units in restructuring of the plane. This is very similar to the idea of restructuring a length into a succession of distances. “Consequently, students found it very difficult to decompose and then recompose the areas of forms to see one form as a composition of others” (Lehrer, 2003).

Formulas for calculating perimeter and area are often presented to students using regular shaped polygons, such as square and rectangles. When students are presented with these figures simultaneously, they become confused and frustrated because the procedures to find perimeter and area of rectangles and squares are similar. “They disguise their lack of understanding by memorizing formulas and plugging in numbers, knowing that they need to use the numbers on the sides of the figures in some way in a formula to obtain the correct answer. Students are often unable to distinguish between perimeter and area formulas because they have not clearly discerned what attribute each formula measures” (Moyer, 2001).

Need for Effective Instruction for Struggling Math Students

The development of mathematics programs that are effective for all students in the classroom is one of the greatest challenges educators face. The student population continues to become more diverse only increasing the importance of developing and utilizing math curricula and
teaching practices that will reach a wide variety of ability levels and learning styles. Research shows the positive outcomes of reform-based mathematics instruction when used with fidelity and long-term (Lubienski, 2006). Research also supports explicit teaching methods of mathematics for adolescents with low-ability levels or diverse learning needs (YanPingXin, Jitendra, and Deatline-Buchman, 2005). It is important to examine reform-based mathematics curricula to determine if this type of instruction can be effective for all students, including low-ability learners in the mathematics classroom.

As educational policies continue to require all students to be integrated into the same regular math class, it is more important than ever to reach the struggling math student. For adolescents already identified "at risk" and achieving below expected standards in mathematics, effective instruction for students in special education is a large area of concern at the national, state, and local levels (Montague & Jitendra, 2006). Teachers of the upper elementary and middle school level mathematics have the added challenge of assuring students have acquired the necessary foundation for higher-level studies of mathematics. Unfortunately, many students enter high school without the necessary understanding of many mathematical concepts, mastery of basic skills, and problem-solving strategies (Montague & Jitendra, 2006).

The National Council of Teachers of Mathematics encourages an integrated approach to instruction using both procedural and conceptual knowledge for all students (NCTM Principle & Standards, 2000). Students with special needs in the math class often receive a large part of their instruction based on algorithms. Many of these students still cannot perform the required algorithms accurately or efficiently. Without balancing the development of conceptual
understanding with learning algorithms, students will never understand important mathematical concepts (Allsopp, Lovin, Green, & Savage-Davis, 2003).

"The reality is that approximately 5-8% of school-age students have memory or other cognitive deficits that interfere with their ability to acquire, master, and apply mathematical concepts and skills" (Geary, 2004). Characteristics these students may have that serve as a barrier to learning mathematical concepts and skills include attention problems, faulty memory retrieval, and metacognition deficits such as the ability to apply appropriate learning strategies, to evaluate their effectiveness, and change strategies when ones in use are not successful (Allsopp, Lovin, Green, & Savage-Davis, 2003). Students with these deficits feel confused about the meaning of the problems, the paths to follow in solving the problems, and reasonableness of solutions. Frequently many students feel incompetent and incapable of understanding the problem thus solving for the answer (Sherman, Richardson, & Yard, 2009).

**Desire to Change Curriculum and Teaching Practices**

Curricular changes and teacher practices are two factors that need to be changed to achieve higher levels of success for struggling math learners (Woodward J., 2006). “One of the main premises of the most current reform efforts in mathematics education is that educators want to empower students mathematically to ensure that they are confident and successful in exploring and engaging in significant mathematical problems” (Allsopp, Lovin, Green, & Savage-Davis, 2003). Without this premise, mathematics becomes something many students try to memorize, making it difficult for students with special needs to be successful as mathematical problem solvers. Understanding what curricula and teaching methods will be effective for these students...
puts classroom educators in a much better position to help all students appreciate the usefulness of mathematics.

2) 1. Do 5th grade students scoring below the 40th percentile on the mathematics part of ITBS improve understanding of concepts of area and perimeter through the regular integration of problem solving tasks throughout a traditional unit of instruction on this concept?
   
   Null Hypothesis: There is no improvement of concepts of area and perimeter through integration of problem solving activities within traditional math instruction.

2. Do 5th grade students scoring below the 40th percentile on the mathematics part of ITBS improve problem solving abilities after experiencing integration of problem based tasks throughout a traditional unit of instruction on this concept?
   
   Null Hypothesis: There is no improvement in problem solving abilities after classroom instruction integrating problem based task with traditional math instruction.

3. Do 5th grade students scoring below the 40th percentile on mathematics of the ITBS tests show an increase in positive self perception as a mathematician after receiving problem based tasks along with the traditional instruction of area and perimeter concepts?
   
   Null Hypothesis: There is no increase in student confidence and positive self perception as a mathematician after integrating problem based math tasks with traditional math instruction.

3) The results of this study will only be used for the writing of a dissertation to complete degree requirements in the Curriculum and Instruction doctorate program.

B. RESEARCH PROCEDURES INVOLVED.

Provide a step-by-step description of all study procedures (e.g., where and how these procedures will take place, presentation of materials, description of activity required, topic of questionnaire)

Version 2-23-09
Participants of the study were determined during the fall semester of 2008. The researcher is familiar with this school district and the teacher of the selected sample class. The characteristics of the class and the school district meet characteristics desired by the researcher: a rural school district with a growing student population in low socio-economic level. The researcher is also familiar with the participating teacher’s style of teaching, classroom atmosphere that is regularly established, and types of curriculum decisions that have been made. The participating teacher has had experience using traditional math curriculum and has also implemented problem solving based activities and curriculum similar to reform based mathematics.

Phases of Data Collection

1. Pre-test: All students in the 5th grade class will be given a problem-based test focusing on the concepts of area and perimeter. Students will also be given a math attitude survey at the beginning of the unit of study.

2. Selected classroom observations: Classroom visits will allow the researcher to collect data by observing the classroom atmosphere, math lessons, and classroom dialogue. Lessons and activities observed will be selected by the researcher based on topics being taught and their benefit to the study.

3. Task-based interviews: Students scoring below the 40th percentile on the ITBS math reasoning and problem solving sections will be given a task-based interview.
4. Post-testing: All students were given a post-test dealing with concepts of area and perimeter presented in a problem-solving, inquiry based format. A post attitude survey will also be given to examine any changes that may have take place in students’ self perception and disposition towards mathematics. Validation of data results was an essential aspect to the post-testing.

Data Analysis

During the course of a case study there is no particular moment when data analysis begins. Analysis of collected information is a matter of giving meaning to first impressions as well as final compilations (Stake, 1995). In formulating any conclusions from the data the analysis should take our impressions and observations apart and give meaning to the parts.

The analysis of the study’s data will include pre and post performance based tasks, math attitude surveys, task-based interviews, previous standardized test scores, and classroom observations. The different sources and types of data will allow the researcher to use methodological triangulation to analyze the data. Methodological triangulation is defined as direct observation with review of records (Stake, 1995). This study will focus on classroom observations, task-based interviews, standardized test scores, student work in the form of performance-based tasks, and attitude surveys to validate the study’s results.

The pre and post performance based tasks will be assessed according to a district established rubric. The rubric assesses student work based on 4 categories: understanding, strategies and reasoning, accuracy and procedure, and communication. These categories are accessible to the students at 4 levels: expert, practitioner, apprentice, and novice. The categories of understanding emphasize content and process standards of mathematics (NCTM Principles and Standards, 2000).

The attitude survey will be totaled for the entire group of participants, establishing any change in students’ self-perception as a “mathematician”. Particularly, the results of the attitude survey taken by the students participating in the task-based interview will be individually interpreted.

The goal of the task-based interviews will be to gain an in depth knowledge of student understanding of the specific concepts being studied. These interviews will also give the researcher insight to any individual misconceptions that occur and establish any patterns and relationships in the misconceptions.
Classroom observations will be made with the researcher taking field notes. The focus of the classroom observation will be the three students identified as scoring below the 40th percentile on two sections of the math component of the Iowa Test of Basic Skills. The key focus of these observations will be the behavior towards mathematics of the identified students and any background conditions that may influence subsequent analysis of the data. The world of education is subjectively structured and holds particular meanings for each of its participants (Cohen, Manion, & Morrison, 2007).

Classroom observations and task-based interviews will be analyzed qualitatively through a descriptive case study supported by performance-based tasks scores, attitude surveys, and prior standardized test scores.

C. DECEPTION.

If any deception or withholding of complete information is required for this activity: a) explain why this is necessary and b) explain if, how, when, and by whom participants will be debriefed. Attach debriefing script.

There is no deception or withholding of complete information during this research study. All involved participants will be completely and honestly informed of procedures of the study and the intended use of the research results prior to the beginning of the study.

D. PARTICIPANTS.

1. Approximately how many participants will you need to complete this study?
   Number 17   Age Range(s) 10-11 yr.olds

2. What characteristics (inclusion criteria) must participants have to be in this study? (Answer for each participant group, if different.)
   Participants of this study need to be in a general 5th grade math class and have scored below the 40th percentile on the Iowa Test of Basic Skills during their 4th grade school year.

3. Describe how you will recruit your participants and who will be directly involved in the recruitment. Key personnel directly responsible for recruitment and collection of data must complete human participant protection training. Attach all recruiting advertisements, flyers, contact letters, telephone contact protocols, web site template, PSPM description, etc. that you will use to recruit participants. If you plan to contact them verbally, in person or over the telephone, you must provide a script of what will be said.

Note: Recruitment materials, whether written or oral, should include at least: a) purpose of the research; b) general description of what the research will entail; and c) your contact information if individuals are interested in participating in the research.

A parental letter of consent, student letter of assent, administrative letter of consent, and classroom teacher letter of consent will be distributed.
4. How will you protect participants’ privacy during recruitment? Note: This question does not pertain to the confidentiality of the data; rather it relates to protecting privacy in the recruitment process when recruitment may involve risks to potential participants. Individual and indirect methods of contacting potential participants assist in protecting privacy.

All students of the class will take part in all aspects of the study, except the task-based interviews. I will randomly interview 5 of the students besides the 3 students that will be the focus of the case study.

5. Explain what steps you will take during the recruitment process to minimize potential undue influence, coercion, or the appearance of coercion. What is your relationship to the potential participants? If participants are employees, students, clients, or patients of the PI or any key personnel, please describe how undue influence or coercion will be mitigated.

The student letter of assent will state that the study is totally voluntary and that not participating in the study will not affect their grade in math class. This will also be emphasized verbally when the researcher distributes and explains the letter of assent to the participants. During the task-based interviews the researcher will again remind the participants that the activity is completely voluntarily, will not affect their grade in math, and he or she can stop taking part in the activity at any time without any negative consequences.

6. Will you give compensation or reimbursement to participants in the form of gifts, payments, services without charge, or course credit? If course credit is provided, please provide a listing of the research alternatives and the amount of credit given for participation and alternatives.

X No  □ Yes  If yes, explain:

7. Where will the study procedures be carried out? If any procedures occur off-campus, who is involved in conducting that research? Attach copies of IRB approvals or letters of cooperation from non-UNI research sites if procedures will be carried out elsewhere. (Letters of cooperation are required from all schools where data collection will take place, including Price Lab School.)

□ On campus  X Off campus  □ Both on- and off-campus

The research study will take place at the Washington Elementary building in the Charles City Community School District in Charles City, Iowa.

8. Do offsite research collaborators involved in participant recruitment or data collection have human participants protections training? Note: Individuals serving as a “conduit” for the researcher (i.e., reading a recruitment script developed by the researcher and not in a supervisory or evaluative role with participants) are not considered key personnel and human participants training is not required.

□ No  □ Yes  □ Don’t know  X Not applicable

E. RISKS AND BENEFITS.

1. All research carries some social, economic, psychological, or physical risk. Describe the nature and degree of risk of possible injury, stress, discomfort, invasion of privacy, and other side effects from all study procedures, activities, and devices (standard and experimental), interviews and questionnaires. Include psychosocial, emotional and political risks as well as physical risks.

There are no risks greater than daily life.

2. Explain what steps you will take to minimize risks of harm and to protect participants' confidentiality, rights and welfare. (If you will include protected groups of participants which include minors, fetuses in utero, prisoners, pregnant women, or cognitively impaired or economically or educationally disadvantaged participants, please identify the group(s) and answer this question for each group.)

The researcher will get parent consent, student assent, administrative consent, and teacher consent through written documents. All students included in the final research report will not be identified by name, gender, race, or ability. All students will be reminded verbally at the beginning of the study and
during task-based interviews of their right to stop taking part in the research study at any time without suffering any negative consequences.

3. Study procedures often have the potential to lead to the unintended discovery of a participant's personal medical, psychological, and/or psycho-social conditions that could be considered to be a risk for that participant. Examples might include disease, genetic predispositions, suicidal behavior, substance use difficulties, interpersonal problems, legal problems or other private information. How will you handle such discoveries in a sensitive way if they occur? These types of discoveries are unlikely. In the case of this happening, the researcher will deal with the situation with extreme discretion with the guidance of my advisor, participating school administration, and professionals if necessary.

4. Describe the anticipated benefits of this research for individual participants. If none, state “None.”

Participants may gain a better understanding of the math concept being studied and increase self-confidence as a math student.

5. Describe the anticipated benefits of this research for the field or society, and explain how the benefits outweigh the risks.

The goal of this study is to gain a better understanding of math curriculum that is effective for student learning at the elementary level. Specifically, the researcher hopes to gain a better understanding of effective curriculum that helps struggling math students at the upper elementary level understand the math concept being studied.

F. CONFIDENTIALITY OF RESEARCH DATA.

1. Will you record any participant identifiers? (Direct personal identifiers include information such as name, address, telephone number, social security number, identification number, medical record number, license number, photographs, biometric information, etc. Indirect personal identifiers include information such as race, gender, age, zip code, IP address, major, etc.)

☐ No X Yes If yes, explain a) why recording identifiers is necessary and b) what methods you will use to maintain confidentiality of the data (e.g., separating the identifiers from the other data; assigning a code number to each participant to which only the research team has access; encrypting the data files; use of passwords and firewalls, and/or destroying tapes after transcription is complete and using pseudonyms.) Also explain, c) who will have access to the research data other than members of the research team, (e.g., sponsors, advisers, government agencies) and d) how long you intend to keep the data.

Indirect personal identifiers including gender and age will be an aspect of this research study. Participants will be given code number to which only the research team has access. No one other than the research team will have access to this data. The data will be discarded at the completion of the writing and approval of the results of the study for the purpose in completing the primary researcher's dissertation.

2. After data collection is complete, will you retain a link between study code numbers and direct identifiers?

X No ☐ Yes If yes, explain why this is necessary and for how long you will keep this link.

3. Do you anticipate using any data (information, interview data, etc.) from this study for other studies in the future?

X No ☐ Yes If yes, explain and include this information in the consent form.
G. ADDITIONAL INFORMATION.

1. Will you access participants' medical, academic, or other personal records for screening purposes or data collection during this study? Note: A record means any information recorded in any way, including handwritten, print, computer media, video or audio tape, film, photographs, microfilm, or microfiche that is directly related to a participant.

   No  X Yes. If yes, specify types of records, what information you will take from the records and how you will use them. Permission for such access must be included in the consent form.

2. Will you make sound or video recordings or photographs of study participants?

   X No  Yes. If yes, explain what type of recordings you will make, how long you will keep them, and if anyone other than the members of the research team will be able to see them. A statement regarding the utilization of photographs or recordings must be included in the consent information.

H. CONSENT FORMS/PROCESS (Check all that apply.)

X Written Consent - Attach a copy of all consent and assent forms.

☐ Oral Consent - Provide a) justification for not obtaining written consent, and b) a script for seeking oral consent and/or assent.

☐ Elements of Consent Provided via Letter or Electronic Display – Provide a) justification for not obtaining written consent, and b) the text for the letter of consent or the electronic display.)

☐ Waiver of Consent  Provide a written justification of waiver of consent process. Note that waiver of consent is extremely rare and would only be granted if the consent process itself posed a greater risk to participants than did participation in the research.
IRB Revisions

Section D (Participants):
Question 3: I will gain parental permission and student assent from all students in the fifth grade for the pre-and post-tests, attitude survey, Iowa Test of Basic Skills scores, classroom observations, and student interviews. I will then determine the students scoring below the 40th percentile. All parents will receive the same parental permission form.

17 students will represent the entire 5th grade class. 5 students will be randomly chosen from the 5th grade class to interview besides the 3 students that are the focus of the case study. The 5 additional students chosen for the task-based interviews will not be chosen based on ITBS scores. The decision to interview 5 additional students was made so that the 3 students (whose ITBS scores are below the 40th percentile) who are the focus of the case study are not singled out. All students involved in the task-based interview will have taken part in pre- and post-tests and the math attitude survey.

Question 4: No revisions

Question 7: I will obtain permission before recruiting participants.

Section F (Confidentiality of Research):
Question 1: I am planning to “match” survey results, classroom observations, and task-based interview results. Each student will be assigned a letter randomly by the cooperating teacher.

Section G (Additional Information):
Question 1: I will check yes for this question and have added an additional statement concerning ITBS scores in the parental permission letter. I have also added contact information for the IRB Administrator in the parental permission letter.

I have attached the updated parental permission letter with this email.

I do not plan to audiotape the task-based interviews.
Re: IRB 08-0195

Dear Ms. Pothast:

Your study, Integrating Problem Solving Within Traditional Math Curriculum, has been approved by the UNI IRB effective 3/23/09, following an Expedited review performed by IRB co-chair, Susan Etscheidt, Ph.D. You may begin enrolling participants in your study.

 Modifications: If you need to make changes to your study procedures, samples, or sites, you must request approval of the change before continuing with the research. Changes requiring approval are those that may increase the social, emotional, physical, legal, or privacy risks to participants. Your request may be sent by mail or email to the IRB Administrator.

Problems and Adverse Events: If during the study you observe any problems or events pertaining to participation in your study that are serious and unexpected (e.g., you did not include them in your IRB materials as a potential risk), you must report this to the IRB within 10 days. Examples include unexpected injury or emotional stress, missteps in the consent documentation, or breaches of confidentiality. You may send this information by mail or email to the IRB Administrator.

Expiration Date: Your study approval will expire on 3/22/10. Beyond that, you may not recruit participants or collect data without continuing approval. We will email you an Annual Renewal/Update form about 4-6 weeks before your expiration date, or you can download it from our website. You are responsible for seeking continuing approval before your expiration date whether you receive a reminder or not. If your approval lapses, you will need to submit a new application for review.

Closure: If you complete your project before the expiration date, or it ends for other reasons, please download and submit the IRB Project Closure form. It is especially important to do this if you are a student and planning to leave campus at the end of the academic year. Advisors are encouraged to monitor that this occurs.

Forms: Information and all IRB forms are available online at www.uni.edu/osp/research/IRBforms.htm.

If you have any questions about Human Participants Review policies or procedures, please contact me at 319.273.6148 or at anita.gordon@uni.edu. Best wishes for your project success.

Sincerely,

Anita M. Gordon, MSW
IRB Administrator

Cc: Jean Schneider, Advisor
Donna Douglas, Co-Investigator
Re: IRB 08-0195

Dear Ms. Pothast:

Your study, Integrating Problem Solving Within Traditional Math Curriculum, has been approved by the UNI IRB effective 03/22/10, following a Continuing Expedited review performed by IRB member Kim Knesting, Ph.D.

Modifications: If you need to make changes to your study procedures, samples, or sites, you must request approval of the change before continuing with the research. Changes requiring approval are those that may increase the social, emotional, physical, legal, or privacy risks to participants. Your request may be sent by mail or email to the IRB Administrator.

Problems and Adverse Events: If during the study you observe any problems or events pertaining to participation in your study that are serious and unexpected (e.g., you did not include them in your IRB materials as a potential risk), you must report this to the IRB within 10 days. Examples include unexpected injury or emotional stress, missteps in the consent documentation, or breaches of confidentiality. You may send this information by mail or email to the IRB Administrator.

Expiration Date: Your study approval will expire on 03/21/11. Beyond that, you may not recruit participants or collect data without continuing approval. We will email you an Annual Renewal/Update form about 4-6 weeks before your expiration date, or you can download it from our website. You are responsible for seeking continuing approval before your expiration date whether you receive a reminder or not. If your approval lapses, you will need to submit a new application for review.

Closure: If you complete your project before the expiration date, or it ends for other reasons, please download and submit the IRB Project Closure form. It is especially important to do this if you are a student and planning to leave campus at the end of the academic year. Advisors are encouraged to monitor that this occurs.

Forms: Information and all IRB forms are available online at http://www.uni.edu/osp/forms-and-standard-documents.

If you have any questions about Human Participants Review policies or procedures, please contact me at 319.273.6148 or at anita.gordon@uni.edu. Best wishes for your project success.

Sincerely,

Anita M. Gordon, MSW
IRB Administrator

Cc: Jean Schneider, Faculty Advisor; Donna Douglas, Co-Investigator
Jennifer Pothast

From: Dr. Susan Etscheidt [susan.etscheidt@uni.edu]  
To: Jennifer Pothast  
Cc: Anita Gordon  
Subject: Re: IRB 08-0195 modification request  
Attachments:

The modifications you have requested are approved.

Susan Etscheidt, Ph.D.  
UNI Institutional Review Board

Jennifer Pothast said the following on 9/15/2009 2:19 PM:  
> This is parental consent form I will be using.  
> Thank you,  
> Jennifer Pothast  
>

Anita Gordon said the following on 8/17/2009 5:22 PM:  
> Dear Susan: Please see request for modification below. Thanks!  
>  
> Anita  
>

https://exchange.wartburg.edu/exchange/jennifer.pothast/Inbox/Re:%20IRB%2008-0195%... 1/14/2010
I would like to modify by approved IRB (#08-0195, Integrating Problem Solving Within a Traditional Math Curriculum). I will be video taping each math session involving the subjects focused on in collecting data. Research data will be collected from the video tapes to add to the qualitative research. The research will not share or use the video tapes in any other way than to complete her dissertation. The video tapes will be destroyed on the completion of her dissertation.

If there are other steps I need to take in modifying this IRB please let me know at your earliest convenience.

Thank you,

Jennifer Neuendorf Pothast
student # 247938
jennifer.pothast@wartburg.edu

Office of Sponsored Programs
213 East Bartlett Hall
University of Northern Iowa
Cedar Falls, IA 50614-0394
PH: 319.273.3217
FX: 319.273.2634

Anita M. Gordon, MSW
Director of Research Services
University of Northern Iowa
213 East Bartlett Hall
Cedar Falls, IA 50614-0394
Phone: 319-273-6148
Fax: 319-273-2634
Dear Dissertation Committee Members,

We are pleased to inform you that Jennifer Pothast (nee Neuendorf) has an approved UNI IRB for her study, Integrating Problem Solving in a Traditional Math Curriculum (IRB # 08-0195).

We have been working with Jennifer on her dissertation proposal (Chapters I-III). She will have a draft of her dissertation proposal and an announcement available on April 20th as required by the guidelines (see next page). Jennifer will be prepared to provide you with a copy of her ?best? proposal no later than April 27th. We would like to plan the public presentation of her dissertation proposal on May 4th or 5th. As you may note we will be having only one week turn-around with the ?best? copy. Please let me know if you would like to have the April 20th draft; otherwise, we will have a copy of her ?best? copy hand-delivered to your office on April 27th.

Please advise me as to what times you are NOT available on Monday, May 4th and Tuesday, May 5th. We will then select a time and reserve a room in SEC for her presentation and proposal.

Jennifer would like to enact her study during May. She will spend the summer analyzing the data and writing Chapters IV and V. We hope she will be able to defend her dissertation during the first weeks of the Fall 2009 semester, so she can fully focus on her job at Wartburg College in Waverly!

Thank You,

Drs. Donna Douglas and Jean Schneider
Co-Chairs, J. Pothast Dissertation Committee
Jennifer Pothast

From: Donna S. Douglas [donna.schumacher@uni.edu]  
To: Jennifer Pothast; Donna Schumacher Douglas; Lynn E. Nielsen; Jean Schneider; Diane Thiessen; Robert.boody@uni.edu  
Cc:  
Subject: Dissertation Proposal Meeting MONDAY May 4 130pm SEC 137  
Attachments:

*ANNOUNCEMENT*

*DOCTOR OF EDUCATION DISSERTATION PROPOSAL PRESENTATION*

Intensive Study Area: Curriculum and Instruction

Jennifer Pothast (Neuendorf), a candidate in the Ed. D. program, will present her dissertation proposal on Monday, May 4, 2009 at 1:30 p.m. in Room 137 SEC. A copy of proposal is available in the College of Education Dean's office.

Title: Integrating Problem Solving Within a Traditional Math Curriculum

In an effort to improve mathematics instruction at the elementary and middle school levels, the proposed qualitative study will examine the effects of using problem solving activities within a traditional math curriculum. The case study will focus on the mathematical concepts of area and perimeter at a 5^th grade level, particularly focusing on students that struggle learning math. To accomplish this study, several problem solving activities along with the traditional math curriculum already in place will be used by a regular classroom teacher when studying the concepts of area and perimeter. Three students will be randomly selected from the set of students scoring below proficiency level (No Child Left Behind, 2001) on Iowa Test of Basic Skills math subtests in a selected 5^th grade classroom. These three students and two other randomly selected students who have scored above the proficiency level will all be given a task-based interview. The three students will also be observed three different times during regular classroom instruction allowing the researcher to gain insight about the students' understanding of the concepts, their attitudes towards mathematics, and their ability to problem solve.

The information gained from the case study will provide additional insight to the ongoing conversation about effective math instruction for struggling learners of math. With this information, math educators will be able to improve math instruction for students that have difficulty learning math concepts along with improving instruction for students of all ability levels.

Dissertation Committee Members:

Dr. Donna Douglas and Dr. Jean Schneider, Co-Chairs

Dr. Robert Boody

Dr. Lynn Nielsen

Dr. Diane Thiessen

https://exchange.wartburg.edu/exchange/jennifer.pothast/Inbox/Dissertation%26Proposal...
Jennifer Peterson

Student Name

247938

Student Number

The above-named student has submitted and presented to us a dissertation proposal entitled:

Integrating Problem Solving Within Traditional Math Curriculum

which we have reviewed and approved.

Edward Douglas 5-4-09

(Dissertation Chair/Co-Chair) circle one

Jean Schurak Schmidt

(Co-Chair or Member) circle one

Robert G. Factions

Member

Diane Gressen

Member

(Member)

(Member)

Dean/Associate Dean
College of Education
Certificate of Completion

The NIH Office of Human Subjects Research certifies that Jennifer Pothast successfully completed the National Institutes of Health Web-based training course "Protecting Human Research Participants".

Date: 04/17/2008

Certification Number: 24589