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A Descriptive Study of the Impact of Planning Time on the Utilization of the National Council of Teachers of Mathematics Process Standards Within the Algebra 1 and Applied Mathematics Subject Fields

Kerri Colleen Lookabill
jklookabill@hotmail.com

A DESCRIPTIVE STUDY OF THE IMPACT OF PLANNING TIME ON THE UTILIZATION OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS PROCESS STANDARDS WITHIN THE ALGEBRA 1 AND APPLIED MATHEMATICS SUBJECT FIELDS

Kerri Colleen Lookabill, Ed.D.
Marshall University
Graduate School of Education and Professional Development

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Committee Chair, Calvin F. Meyer, Ed.D.
Teresa R. Eagle, Ed.D.
Lisa A. Heaton, Ph.D.
Rhonda S. Shepperd, Ed.D.

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ABSTRACT

A Descriptive Study of the Impact of Planning Time on the Utilization of the National Council of Teachers of Mathematics Process Standards within the Algebra 1 and Applied Mathematics Subject Fields

Planning practices are necessary requirements for effective instruction. Their importance is illustrated in the guidelines produced by several national organizations such as The Interstate New Teacher Assessment and Support Consortium (INTASC), The National Board for Professional Teaching Standards (NBPTS), and The National Council of Teachers of Mathematics (NCTM). Planning time is considered important by teachers at the grassroots level in order for them to develop thought-provoking lessons that allow students to make connections and form meaning as well as to reflect on previous lessons in order to make improvements for subsequent lessons. Collaborative planning is also considered important; however, it usually occurs with respect to block schedules, inclusion of special education students in the regular classroom, and the middle school model of education. The question exists as to what impact planning practices may have on high school regular education Algebra 1 and Applied Math classrooms.

The purpose of this study is to investigate whether the amount of time a high school Applied Math or Algebra 1 teacher spends planning, individually or collaboratively, affects the frequency of utilization of practices recommended by the NCTM. The population was described as secondary (grades 9-12) Algebra 1, Applied Math 1, and Applied Math 2 teachers in the public schools in West Virginia. Data was collected using an instructional practices survey constructed by the researcher.

This study utilized ANOVA tests and t-tests for independent samples to determine if differences existed in the mean frequency of use of NCTM recommended instructional practices based on length of planning time. Findings indicated that teachers who planned longer, both individually and collaboratively, had significantly higher mean frequency scores. Length of planning time also resulted in differences when the NCTM recommended practices were divided into five process standards. It can be concluded that longer planning times not only contribute to a higher mean frequency of NCTM recommended strategies but also to a larger variety of strategies as indicated by significant differences in the five NCTM process standards. It was also determined that statistically significant differences occurred in planning times and NCTM scores based on demographic variables.

DEDICATION

I dedicate this dissertation to my family. I dedicate it to my husband Jimmy who spent much time alone or taking care of the children while I spent time writing. I dedicate it to my children Caden and Colleen who wondered why Mommy often sat at the computer instead of playing with them. I dedicate it to my parents Gene and Cathy Crotty who instilled in me the desire to persevere and succeed at my goals.

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CHAPTER ONE: INTRODUCTION

Misulis (1997) contended that "regardless of the teaching model and methods used, effective instruction begins with careful, thorough, and organized planning on the part of the teacher" (p. 45). Planning has been an important aspect of the education process for many years. Early planning models developed by experts such as Tyler followed a rational model: develop objectives, develop activities to help students achieve objectives, and evaluate the students to determine if the objectives have been met (Sardo-Brown, 1990: Yinger, 1980; Zahorik, 1975). However, the planning process has evolved to focus more on designing learning activities that meet the diverse needs of the students to ensure that learning has taken place (Baylor & Kitsantas, 2001; Ornstein, 1997; Panasuk, Stone, & Todd, 2002).

Planning practices are necessary prerequisites to effective teaching (An, 2001; Decker, 2000; Misulis, 1997; Panasuk et al., 2002; Wolf, 2003). Their importance is illustrated in the guidelines produced by national organizations such as The Interstate New Teacher Assessment and Support Consortium (INTASC), The National Board for Professional Teaching Standards (NBPTS), and The National Council of Teachers of Mathematics (NCTM). Planning time is deemed important by teachers at the grassroots level in order for them to develop thought-provoking lessons that allow students to make connections and form meaning as well as to reflect on previous lessons in order to make improvements for subsequent lessons (Alperin, 2001; Decker, 2000; Viale, 2005; Wolf, 2003).

Specifically, collaborative planning is recommended as a method to improve instruction. Goodlad (1984) believed there was no infrastructure to encourage communication among teachers to improve their teaching or solve work place problems. Erickson (1993) contended that impediments to ideal mathematics instruction consisted of lack of preparation time and lack of collaboration with peers. Adajian (1996) found that teachers who collaborated with other teachers used higher levels of reformed mathematics instruction, and it was a strong recommendation of the NCTM that math teachers reform mathematics instruction. Lesson improvement is supported in studies by Corrick and Ames (2000) and Welch (2000). Corrick and Ames described a successful program in which library media specialists (LMS) collaborated with content area teachers in order to better prepare lessons for the students. Welch (2000) studied two teams of teachers at the elementary school level. He determined that the team who had a longer planning time utilized a greater variety of team-teaching strategies than the other team. Taylor (2004) directly studied the impact of collaborative planning on the quality of lesson plans, and findings showed evidence that a significant positive correlation existed between collaboration and lesson plans that received higher scores on a lesson plan scoring system. Collaborative planning is currently an emphasis in several educational areas such as classes where inclusion occurs, the middle school approach to teaching, and block scheduling which usually occurs at the high school level (Crow & Pounder, 2000; Holschen, 2000; Rose, 2001).

The NCTM is one of the national organizations that suggests planning time is critical to effective teaching and implementation of the standards. In 2000, Lee V. Stiff, NCTM president, urged a renewed attention to good lesson planning and lesson implementation in order to improve mathematics learning (Panasuk et al., 2002). The main recommendation of the NCTM is the development of conceptual understanding of mathematics through an inquiry approach to teaching and learning that influences students' meaningful learning of mathematics (D'Ambrosio, Boone, & Harkness, 2004).

The NCTM's most recent standards document, *Principles and Standards* (2000), outlines its recommendations on the mathematical content that should be taught and the most effective methods to instill the content in the students. Specifically, the NCTM emphasizes five process standards that will help define effective teaching: problem solving, reasoning and proof, communication, connections, and representations (Panasuk et al., 2002). The process standards may be implemented by various instructional strategies such as cooperative learning, writing, and mathematical discourse (D'Ambrosio et al., 2004; Maccini & Gagnon, 2000; Pape & Smith, 2002; Simon, 1992). Other instructional techniques that helped improve the NCTM process standards include manipulatives and technology (Burrill, 1998; D'Ambrosio et al., 2004; Erickson, 1993; Maccini & Gagnon, 2000; Panasuk et al., 2002). The literature is abundant on effective instruction of mathematics.

Adajain's (1996) findings align with the recommendations of NCTM in that collaborative planning practices influence the teaching of reformed mathematics. The NCTM published *Principles and Standards* in 2000. Before any of the national standards were published, mathematics was regarded as a body of facts and procedures to be mastered (Pape & Smith, 2002). The NCTM standards have encouraged understanding and problem solving over rote practice and procedures and active learning over transmission of information by teachers. In addition, the standards have had several implications for mathematics education. Learning math is important for everyone. Also, learning math does not mean memorizing and repeating, but rather investigating, conjecturing, reasoning, and reflecting (Romberg, 1993). Traditional teaching methods such as drill and practice with pencil-and-paper, memorization of rules and algorithms, and note-taking from lectures were de-emphasized while reform oriented strategies such as cooperative work, complex computations with calculators, and collection of data were emphasized (Klein, 2003; NCTM, 1995).

Positive effects of the NCTM standards included a large membership increase, an increase in Eisenhower and National Science Foundation (NSF) funding of projects to develop new instructional materials, and substantial changes in textbooks (Burrill, 1997; Martin & Berk, 2001; Reyes & Robinson, 1999; Romberg, 1993). By 1997, 46 states had created their own mathematics standards and aligned them with those of the NCTM (Burrill, 1997; Martin & Berk, 2001). Implementation of the standards appears to have increased national test scores as well. Scores on the Scholastic Aptitude Test (SAT) math portion and the National Assessment of Educational Progress (NAEP) improved in the late 1990s. Fourth graders scored above average on the Third International Mathematics and Science Study (TIMSS) (Burrill, 1998). Research showed that schools with the highest level of reform scored above the state means on mathematics tests (Felner et al., 1997). The Core-Plus Mathematics Project (CPMP) published evidence that showed improvements in skills as a result of the standards. The results of the study indicated that students using a curriculum based on the standards significantly outperformed students in a control group on measures of problem solving and reasoning (Reyes & Robinson, 1999).

The issues of instructional planning time and effective teaching practices are relevant at the local level, also. West Virginia Board of Education Policy 2510 (2006) outlines regulations for a quality education. The guidelines regulate the amount and features of planning time for state teachers. Policy 2520.2 (WVBOE, 2003) outlines the West Virginia mathematics Content Standards and Objectives (CSOs). The CSOs are aligned directly with the content standards of the NCTM.

In conclusion, research shows that adequate planning time and collaborative planning enhance effective teaching practices (An, 2001; Decker, 2000; Glatthorn, 1993; Misulis, 1997; Panasuk et al., 2002; Welch, 2000; Yinger, 1980). In addition, time has been identified as a critical aspect for successful school change (Livingston, 1994). The NCTM has urged that teachers reform their manner of mathematics instruction and has outlined its recommendations for effective teaching in Principles & Standards (2000). Moreover, the literature has supported the NCTM recommendations (Artzt & Armour-Thomas, 1999; Glick, Ahmed, Cave, & Chang, 1992; Good, Reys, Grouws, & Mulryan, 1989; Maccini & Gagnon, 2000; Morrone, Harkness, D'Ambrosio, & Caulfield, 2004; Serafino & Cicchelli, 2003; Smith & Geller, 2004; St. Clair, 1998; Stigler & Hiebert, 2004; Ysseldyke, Betts, Thill, & Hannigan, 2004). The process standards proposed in Principles & Standards align closely with the effective teaching strategies described in planning literature. This leads to the question as to whether more time allowed for individual and collaborative planning may influence teacher implementation of NCTM recommended teaching practices.

Problem Statement, Purpose, and Research Questions

Research has indicated that the longer planning time afforded by block scheduling may contribute to a more varied repertoire of instructional techniques utilized by teachers (Banbury, 1998; Quinn, 1998). In addition, collaborative planning time is beneficial in the instruction of special education students who have been included in a regular classroom as well as middle school students (Crow & Pounder, 2000; Epstein, 1999; Rose, 2001; Warren & Payne, 1997). During the last ten years, most of the studies that involved planning time and collaborative planning focused on the middle school concept of interdisciplinary teams of teachers, the inclusion of special needs children in a regular classroom with the help of a team that includes a special educator and a regular educator, or the implementation of block scheduling. Taylor (2001) determined that the most common collegial interactions among high school mathematics teachers were considered teacher talk, and that observing and critiquing each other's teaching was a source of uneasiness. Generally, the only time collaborative planning occurred in a form more structured than teacher talk was when required by administrators. Banbury (1998) and Pruitt (1999) studied whether the presence of block scheduling impacted the number of effective instructional practices utilized by the teachers; however, the focus of their studies was on the number of years experience in teaching and not the duration of planning time or presence of collaborative planning. These studies relate to planning time or effective instructional practices, but the current study focuses singularly on the impact of duration of individual or collaborative planning time as it affects high school teacher utilization of the NCTM's five process standards. In fact, An (2001) specifically recommended further study on the impact of planning time on mathematics instruction. Recent literature does not reveal if alternate models of planning time as described in middle school, inclusion, and block scheduling models are being utilized in the teaching of mathematics in regular classrooms at the high school level.

The purpose of this research was to investigate whether the amount of time a high school Applied Math or Algebra 1 teacher spends planning, individually or collaboratively, affects the frequency of utilization of practices recommended by the NCTM. Teacher use of instructional strategies was examined based on an adaptation of the Butty instrument (Butty, 2000).

This issue will be examined by considering the following research questions:

Research Question 1. What differences exist in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of individual planning time?

Research Question 2. What differences exist in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of collaborative planning time?

Operational Definition of Basic Terms

The following operational definitions were used to examine the research questions of this study:

1. Amount of individual planning time - The time in minutes spent by an individual teacher preparing lessons and materials prior to instructional delivery or time spent reflecting on effectiveness of instruction as reported by the teacher.

2. Amount of collaborative planning time - A common planning time that two or more teachers share to plan lessons prior to instruction or time spent reflecting on effectiveness of instruction as reported by the teacher.

3. Frequency of use - The amount of use of the NCTM process standards as reported by the teacher.

4. Problem solving - An NCTM process standard that means engaging in a task for which the solution method is not known in advance.

5. Reasoning and proof – An NCTM process standard that means thinking analytically and noting patterns, structures, and regularities in real-world situations and symbolic objects as well as being able to conjecture and prove.

6. Communication - An NCTM process standard in which ideas are shared and understanding is clarified as ways to build meaning and permanence of ideas.

7. Connections – An NCTM process standard in which students connect mathematical ideas, relate mathematics to other subjects, and relate mathematics to their own interests and experiences.

8. Representation – An NCTM process standard in which students capture a mathematical concept or relationship in some form or the actual form itself that is externally or internally observable by students.

9. Algebra 1 teacher – A teacher who is certified by the West Virginia State Department of Education to teach mathematics in grades 5-12, grades 5-9, or Math through Algebra 1.

10. Applied Mathematics teacher - A teacher who is certified by the West Virginia State Department of Education to teach mathematics in grades 5-12, grades 5-9, or Math through Algebra 1.

Methods

The study's design was descriptive. The population consisted of secondary (grades 9-12) Algebra 1, Applied Math 1, and Applied Math 2 teachers in West Virginia because it was the intent of the researcher to study practices at the secondary school level only. The independent variables were the length of individual planning time and the length of collaborative planning time engaged in by the teachers. The dependent variable was the frequency of use of various instructional practices. The appropriateness of use is very difficult to measure; therefore, the focus was on frequency of use rather than appropriateness of use. The researcher intended to determine if there was a difference in the frequency of use based on duration of planning time. The instrument was field tested before being sent to the population. Analysis of variance (ANOVA) tests were completed to determine if there were statistical differences in the dependent variables along with the Fisher's Least Significant Difference (LSD) post hoc test to determine exactly where any significant differences occurred.

Delimitations

The researcher limited several aspects of the study. The population of the study was limited to West Virginia mathematics teachers in grades 9-12. More specifically, the study focused on Applied Math and Algebra 1 teachers. Only those surveys marked by teachers of these courses were utilized for data collection. It was inappropriate to generalize results to areas vastly different than the schools in West Virginia such as those in urban settings or to teachers of other mathematical content areas. In addition, the population was limited to high school teachers although Algebra 1 is also taught at the middle school level because it was the intent of the researcher to apply the results of the study to high schools in the state. Finally, the instructional strategies were defined by the National Council of Teachers of Mathematics standards. There is abundant literature on effective mathematics instruction, and the NCTM is recognized as the leading authority on mathematics in the United States as well as other parts of the world.

Limitations

There were several limiting aspects of the study beyond the control of the researcher. First of all, this study highlighted the effects of planning time on frequency of use of specific instructional strategies. Other variables such as years experience, age, and highest degree completed may confound the results of emphasis on instructional activities. Another limitation of the study was that the researcher relied on data provided by the West Virginia Department of Education. The data that were provided may have errors in the teaching status of the population. Finally, the dominant format of the survey was restricted choice questions. The choices reflected what the researcher perceived as important, not necessarily what the respondents saw as important. To alleviate this limitation, there was an area on the survey that asked for comments so that the respondents could provide other information that they deemed as important.

Assumptions

This study examined planning time versus the use of specific instructional strategies. The study assumed that the participants planned at home as well as at school. The extra time spent planning at home may have contributed to a variation in planning times. Without this assumption, the reported planning times would fall in a more narrow range of times. The study also assumed that teachers utilize several of the strategies enumerated on the survey instrument, even if the strategies were traditional. With respect to the survey instrument, the study assumed that the participants understood the definitions of planning time as described by the researcher. Finally, the participants completed a self-reported survey. The study assumed that the reported responses accurately represented their perceived instructional practices.

Significance

Currently, there is much educational interest in teacher planning as well as on implementation of standards. This study made a great contribution to the field of mathematics education. First of all, the study has significance for mathematics teacher preparation programs. Preservice teachers spend hours developing lesson plans while in methods courses only to fill in little boxes in lesson plan books after entering the work force. Preservice teachers are seldom taught the practice of reflection or collaboration with other teachers. Only recently have preservice teachers been instructed in how to implement standards-based instruction. Cooper (1996) recommended that preservice teachers have more time to reflect on lessons they have observed or taught. Lederman and Niess (2000) suggested that the developmental level of the preservice teacher should be a factor in the complexity of lesson plans required by teacher educators. Henning

(2004) concluded that a collaborative model for student teaching may reinforce instructional beliefs and practices that align with standards-based instruction.

Another significant impact of the study may be with mathematics instruction. The research states that teachers who have longer planning times as well as collaborative planning time are especially effective with students such as those in special education and middle school (Burns & Reis, 1991; Epstein, 1999; Erickson, 1993; Rose, 2001; Warren & Payne, 1997; Welch, 2000). What little research has been conducted with high-school teachers shows that collegiality and planning time are lacking and that high-school teachers favor attendance at workshops as ways to improve instruction rather than interactions with colleagues (An, 2001). State education systems are searching for research-based evidence that describes how to improve instruction.

The study may also influence inservice teacher training. Current inservice training programs attempt to teach strategies in quick infrequent sessions. Reflection and sustained practice in the strategies are not emphasized. McCutcheon (1980) asserted that inservice days, teacher workdays, and faculty meetings could be utilized for professional reflection by both teachers and administrators. Smylie (1989) reported that teachers desired time to work with, consult with, and observe other teachers rather than attend graduate courses or district inservice training. Canady and Rettig (1995) recommended that blocks of days be incorporated within the school year to be utilized for planning and staff development.

A final significance of the study may be changes in school structure. Evidence exists that extended planning afforded by block scheduling results in teacher usage of a larger repertoire of instructional techniques (Banbury, 1998; Holschen, 2000; Quinn, 1998). Livingston (1994) and Caron and McLaughlin (2002) recommended that schools hire a substitute teacher to work permanently in the building to allow teachers extended individual and collaborative planning times. Viale (2005) asserted that real change in educational policies could not occur if models of planning did not change to include deeper reflection and collaboration. At the same time, Viale suggested that independent planning time was critical because it allowed teachers to engage in mental planning activities and that biweekly collaborative planning meetings was optimum. This study may garner the necessary data to provide the evidence needed to create reform with planning time.

Organization of the Study

Chapter 1 is an introduction that discusses the background of the study as well as the problem that led to the study. In addition, the study's purpose, limitations, and operational definitions are presented. Chapter 2 consists of a comprehensive literature review that relates planning research to effective instructional techniques for mathematics. Chapter 3 presents the details of how the study will be completed and includes a description of the instrument, population, etc. Chapter 4 reports the findings of the study as well as the statistical analysis of the data. Chapter 5 includes a summary of the study, a discussion of the findings, and recommendations for future practice and research.

CHAPTER TWO: REVIEW OF LITERATURE

This study investigates whether the amount of time a secondary (grades 9-12) Algebra 1 or Applied Math teacher spends planning, individually or collaboratively, affects the frequency with which they use the National Council of Teachers of Mathematics' (NCTM) five process standards. The areas to be discussed in the literature review include historical background on instructional planning, research on individual planning practices, research on collaborative planning practices, historical background of the NCTM standards documents, a detailed description of each NCTM process standard, and research on planning as it affects instructional practice.

History of Research on Planning

Instructional planning is an essential part of the educational process. The early planning models, proposed in the 1950s and 1960s, by educators such as Tyler and Taba were rational models in which the steps were sequential and orderly: specify objectives, select learning activities, organize learning activities, and specify evaluation procedures (Sardo-Brown, 1990; Yinger, 1980; Zahorik, 1975). Since then Zahorik (1975) determined that teachers from a variety of grade levels, subjects, and experience levels made decisions based on content first and then on other areas such as activities and materials; decisions made about objectives were rarely a high priority with the teachers studied. In fact, Zahorik asserted that teachers who follow the rational planning model are less sensitive to student needs and interests (1970). Peterson, Marx, and Clark (1978) concurred with Zahorik in that teachers spent the most planning time on content, instructional processes, and objectives in decreasing order.

The rational planning model expanded in the 1980s. Yinger (1980) proposed a process model of planning with three stages: problem-finding, problem formulation/solution, and a third step consisting of implementation, evaluation, and routinization. His model thus allowed for the teacher to act as a problem solver and decision maker in order to best facilitate student learning. Madeline Hunter's model of planning was heavily utilized in the 1980s. Her model referred to as Mastery Learning, included a review of previous lesson, an anticipatory set that gained the students' attention, an explicitly stated objective, a presentation of new information from the teacher, a modeling of examples by the teacher, a check for understanding, a guided practice session, and then independent practice (Ornstein, 1997).

Contemporary models of planning have emerged that are modifications of previous models. Sardo-Brown (1990) reported that teachers who were required to use the Hunter model of planning did so in conjunction with other models. The alternative models utilized included choosing a theme to teach, developing goals to cover, researching factual information, planning activities, and choosing evaluation procedures. The teachers also admitted to borrowing parts of lessons from other resources such as other teachers and inservice speakers and developing the plans in a manner that coincided with their own information-processing styles; a process that Small, Sutton, Miywa, Urfels, and Eisenburg (1998) referred to as berrypicking.

A specific contemporary planning model was developed by Baylor and Kitsantas (2001). They investigated the effect of the Instructional Planning Self-Reflective Tool (IPSRT) on preservice teachers' attitudes toward instructional planning. The IPSRT, which encourages self-monitoring and self-evaluation, was utilized by half of seven sections of students in an instructional technology class. The other half received only a review of planning. The experimental group exhibited greater skill acquisition and more positive attitudes toward instructional planning. Another contemporary model was developed by Panasuk et al. (2002). It was named the Four Stages of Lesson Planning (FSLP) and directly refers to mathematics education. The FSLP is based on a constructivist perspective in which instruction should be designed to help students make connections between new information and existing cognitive structures. The FSLP includes (a) a listing of objectives, (b) an assignment of homework that makes connections between previous and new lessons, (c) the implementation of appropriate developmental activities, and (d) the utilization of mental mathematics as a means to assess the readiness of the students to learn new material.

The importance in planning is now emphasized as standards recommended by several national education organizations. The Interstate New Teacher Assessment and Support Consortium (INTASC) recommends that beginning teachers have "the ability to conceptualize, plan, and select materials for instruction, emphasizing the importance of connecting the curriculum to students' experiences" (Blank, 2004, p. 27). The standard also requires that teachers be able to adjust plans and revise them based on changing circumstances as well as value planning as a collegial activity. The International Society for Technology in Education (ISTE) requires beginning teachers to be able to plan effective experiences supported by technology (Peterson & Bond, 2004). The National Board for Professional Teaching Standards (NBPTS) also maintains standards that involve instructional planning. The NBPTS' third core proposition asserts that teachers are responsible for managing and monitoring student learning. Part of proposition three states that teachers should know about instructional planning: identifying objectives, developing activities, and drawing upon necessary resources. Furthermore, the NBPTS' fifth proposition states that teachers are part of learning communities, and therefore must collaborate to plan the instructional program for the school (NBPTS, 2000).

The NCTM, in addition to other national organizations, emphasizes the importance of instructional planning. In 2000, Lee V. Stiff, the NCTM president, urged renewed attention to good lesson planning and lesson implementation in order to improve mathematics learning (Panasuk et al., 2002). The document created by the NCTM is *Principles and Standards*. The standards are composed in part by principles which describe features of high-quality mathematics education. One of the principles, the Teaching Principle, contends that teachers need to understand what students know, what the students need to know, and then help the students to learn it well. To accomplish this principle, teachers must "balance purposeful, planned classroom lessons with the ongoing decision making that inevitably occurs as teachers and students" interact during the lesson (p. 18). Furthermore, "opportunities to reflect and refine instructional practice are crucial" (p. 19), thus showing the importance of reflection as a necessary part of instructional planning (National Council of Teachers of Mathematics [NCTM], 2000). *Principles and Standards* also emphasize an Equity Principle in which all students are entitled to a high quality mathematics education. The decisions teachers make in the classroom are essential in order to meet the experiences, interests, and abilities of all students in the room. Finally, the NCTM's position statement about highly qualified teachers asserts that all teachers "must know how to plan, conduct, and assess the effectiveness of mathematics lessons and know how and when to make teaching decisions" (NCTM, 2005).

National organizations are not the only groups to emphasize planning time. Local educational entities also address planning. Policy 2510 developed by the West Virginia Department of Education outlines the regulations that are designed to improve teaching and learning in the public schools. Section 7 of the policy describes the responsibilities of the county school board which includes ensuring that all teachers "are provided a duty free planning period that is the length of the usual class period and is not less than 30 minutes" (WVBOE, 2006, p. 37). Section 8 of the policy describes school-based responsibilities of the principal and staff among which are several aspects of planning: (a) the teachers should be prepared and initiate instructions when students enter the classroom; (b) the teachers should develop and utilize written lesson plans that focus on the content standards and objectives for the course; and (c) the teachers should provide instruction that is organized, sequential, and based on prior knowledge. Finally, Policy 2510 encourages teacher use of juried lesson plans which are instructional units that have been aligned to content standards, reviewed by teachers, and demonstrated effectiveness in classrooms (WVBOE, 2006).

Conceptual Framework

Planning may follow constructivist methods. Lederman and Niess (2000) asserted that teachers who exhibited a constructivist approach to planning filled the lesson plan with questions and activities that guided the students' thinking to the desired outcomes. Bias (n.d.) described additional constructivist models for planning instruction. She explained the Brooks and Brooks model: pose problems of relevance to the students, structure learning around primary concepts, seek and value students' points of view, adapt curriculum to align with students' suppositions, and assess learning in the context of teaching. Bias also explained a backwards planning model by Wiggins and McTighe: identify desired results, determine acceptable evidence, and plan learning experiences and instruction. Finally, Bias explained Kierstead's idea of project-based learning. Kierstead recommended that students engage in a variety of activities; put their thoughts into words; create authentic products; use methods, processes, and vocabularies inherent to the content; apply the concept across subject matters; and weigh personal norms against new knowledge (Bias, n.d.).

National organizations such as the NCTM support constructivist classrooms and constructivist planning. The main recommendation of the NCTM is the development of conceptual understanding of mathematics through an inquiry approach to teaching and learning that influences students' meaningful learning of mathematics (D'Ambrosio et al., 2004). *Principles and Standards* (2000) details the NCTM's Learning Principle as "Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge" (p. 20). Thus, the theoretical basis of the NCTM's reform movement is constructivism.

Purpose and Value of Planning

Planning is an important activity for practicing teachers. It may be defined as a set of "processes in which the teacher visualizes the future, inventories means and ends, and constructs a framework to guide his or her future actions" (Lederman & Neiss, 2000, p. 57) or simply as a set of decisions the teacher makes during the instructional process (Clark & Peterson, 1986; Zahorik, 1975). Yinger (1980) asserted that the goal of instructional planning is to successfully implement classroom learning activities. McCutcheon (1980) ascertained that planning is composed of three intertwined aspects: the planning process, the effects on the curriculum, and the influences on planning. Bullough (1987) defined planning as a problem solving process.

Planning time is important for many reasons. It has also been asserted that offering ample time for reflection and continued learning contribute to successful learning opportunities for teachers (D'Amrosio et al., 2004; Simon, 1992). Simon also asserted that reflection enables teachers to articulate for themselves the principles of instructional planning. In addition, the literature supports adequate planning time as a prerequisite to effective teaching which in turn should improve learning. Longer planning time contributes to a more student-centered instructional approach (An, 2001), as well as to lessons that better promote thinking skills (Burns & Reis, 1991). Welch (2000) concluded that longer planning time is associated with use of a greater variety of instructional strategies.

Adequate planning time is a valuable commodity for teachers. Buechler (1991) reported that the teachers in an Indiana Education Policy Center study placed a higher value on more planning time than on systematic restructuring as a means to school improvement. Pitler (1997) studied planning practices of elementary teachers and determined that the teachers perceived that planning time was both effective and valuable. However, many teachers believed that planning time was needed to prepare for students (grading, making copies, working with students, meeting with parents), and that true instructional planning took place after school at home.

Collaborative Planning

Definition of Collaborative Planning

Collaborative planning occurs when two or more teachers work together to plan lessons prior to instruction or to reflect on the effectiveness of a previously taught lesson. Friend and Cook (1990) referred to collaboration as interaction between at least two equal parties voluntarily employed in shared decision-making in an effort to achieve a common goal. West (1990) defined collaboration as an eight step process of interactive planning, decision-making, or problem-solving among two or more team members. Some refer to collaboration as collegiality (Taylor, 2001; Walston, 2001).

Collaborative planning has been described as a method to improve instructional techniques in the classroom. In fact, educators as long ago as 1980 saw lack of opportunity to discuss plans with others as a negative influence on planning (McCutcheon, 1980). Zahorik's (1987) sample of teachers rated interactions with colleagues as a more useful means to improve teaching than university courses, professional journals, or inservice sessions. A finding in Bullough's (1987) case study of a new seventh grade teacher was that the teacher received little help from the other teachers, even from her teacher leader. This finding led Bullough to define planning as a "collaborative, dialogical, … form of problem solving" (p. 248). During the third year of a staff development project in Long Island that utilized collaborative planning to improve student learning, the teachers collaboratively planned units of instruction that were taught during the school year (Ogle, 1988/1989). The teachers regrouped after lesson presentations and reflected on what strategies worked best to encourage the students to become strategic learners. All of the teachers in the project responded favorably to collaborative planning. Buechler's (1991) sample of teachers from all grade levels reported that they needed more time to collaborate in order to plan instruction and develop curricula.

Erickson (1993) reported that impediments in implementing ideal mathematics teaching included lack of preparation time and lack of collaboration with peers. It has also been asserted that offering ample time for reflection, collaboration, and continued learning contribute to successful learning opportunities for teachers (D'Amrosio et al., 2004; Simon, 1992). The teachers in Pitler's (1997) study who had completed a Quality Performance Accreditation (QPA) process stated that they needed more collaborative planning time; however, the teachers who had not been through the QPA process neither expressed the need for collaboration nor were observed participating in collaboration.

Current research also provides evidence for the importance of collaboration among teachers. Decker (2000) asserted that teachers are like students in that they need time to read, reflect, and collaborate with others to be successful in their practices, so more time needs to be built into the daily schedule in order to follow these recommendations. Martin (2001) cited several benefits of collaboration: (a) broadening of teaching skills, (b) novice teachers gaining information from more experienced teachers, (c) experienced teachers gaining current information from novice teachers, (d) enhanced teacher morale as a result of reduced isolation, (e) development of a more consistent curriculum, (f) sharing of knowledge on how to reach diverse student populations, (g) peer recognition of classroom accomplishments, and (h) problem-solving. Henning (2004) studied student teachers some of whom were in an experimental configuration called a Collaborative Inquiry Group Model. The students in the

Collaborative Inquiry Group Model perceived stronger support from cooperating teachers and university teachers in their efforts to develop engaging lesson plans. Also, three of the eight students did not have initial beliefs consistent with national standards, yet their beliefs and practices evolved to align with those of the mentors whom they perceived as supportive. Furthermore, Henning reported that the teachers in the collaborative model utilized classroom discourse more frequently than their counterparts in the traditional model, and that the discourse is consistent with standards-based instruction. Henning concluded that a collaborative model for student teaching may reinforce instructional beliefs and practices that align with standards-based instruction.

Collaboration is also supported by the findings from national organizations. The Glenn Commission Report (National Commission on Mathematics and Science Teaching, 2000) made several references to the importance of collaboration. First of all, it asserted that "time for peer contact and joint lesson planning are vital sources of both competence and nourishment for all teachers" (p. 18). It also recommended the creation of Inquiry Groups as communities of learning in each school system became an Internet portal containing an online professional journal in which teachers could share instructional strategies with peers. Finally, the report urged all teachers to collaborate with colleagues to set goals for areas of instructional improvement.

The NCTM also recommends collaboration among teachers. An NCTM sponsored professional development called Teachers Teaching with Technology, or T^3, regularly utilizes collaboration. Participants in the T^3 workshops must create and modify lessons that are critiqued by peers. In addition, groups of teachers create lesson plans and present them using technology. Finally, master teachers share their ideas and strategies with the participants (Walston, 2001).

The No Child Left Behind Act (NCLB), formerly Title 1, recommends collaboration among teachers. LeTendre, Wurtzel, and Boukris (1999) described how Title 1 funds could be used by schools for teachers to experiment with new models of planning time such as collaborative versions or back-to-back planning periods in order to prepare high-quality lessons or to learn from each other. Presently, Title II Part B of the NCLB Act provides grant money to math and science teachers, giving them the opportunity and time to collaborate with experienced teachers and university faculty (USDE, 2002).

Collaborative planning is not pervasive throughout education; however, it is becoming more popular. It is currently an emphasis in several areas such as classes where inclusion occurs, the middle school approach to teaching, and block scheduling which usually occurs at the high school level.

Collaboration with Respect to Inclusion

Collaborative planning is often used in context with mainstreaming special education students in regular classrooms. Warger and Rutherford (1993) as well as Goldstein (2004) suggested co-teaching as an effective means to teach students with special needs. Warger and Rutherford's study demonstrated that a collaborative approach improved the social skills of students with special needs, whereas Goldstein described a situation in which the achievement levels of special needs students were improved by teacher collaboration. As part of the co-teaching process, the researchers cited collaborative planning time, especially for reflection and review, as a key component to the model's success.

Giangreco (1997) identified collaborative planning time as one of the common features of schools where inclusion has succeeded. Rose's (2001) findings corroborated Giangreco's; the teachers he interviewed indicated that learning support assistants would be necessary to help students with special needs and that the arrangements for this partnership would need constant attention and time. Furthermore, Rose indicated that time for teacher preparedness is a critical factor in inclusion. Caron and McLaughlin's (2002) results also concurred with Giangreco's. They studied Beacons of Excellence schools to determine common components and identified collaborative time between general educators and special educators as a key characteristic of the Beacon schools. The researchers emphasized that time was a crucial support to collaborative practices, and formal collaborative time on a regular basis was present in three of the six Beacon schools (Caron & McLaughlin, 2002).

Rose's (2001) results mirrored the results of a study by Epstein (1999). Epstein's recommendations were based on responses from a sample of special and regular educators. He studied strategies to improve home school communication for students with disabilities and determined that mutual planning time between regular and special educators was one of the most highly ranked recommendations by the teachers who were surveyed. Specifically, middle school teachers ranked mutual planning time the highest. On the other hand, the high school teachers ranked as most important the recommendation that regular and special education teacher teams mentor less experienced teachers.

Jitendra, Edwards, Choutka, and Treadway (2002) described a collaborative approach to planning in content areas that would include special needs students. Content area educators and special educators combined their areas of expertise to align content-learning outcomes with content standards in core academic areas. Jitendra et al. suggested that the teachers collaborate to develop a unit organizer that outlines: (a) unit background information; (b) a content goal statement; (c) content learning outcomes such as facts, concepts, or principles; (d) intellectual processes such as reiteration, summarization, or evaluation; and (e) key vocabulary. Furthermore, the researchers recommended that the teachers compile a collection of instructional activities along with potential accommodations. Finally, Jitendra et al. advised that content area and special educators collaboratively plan assessment strategies that may be utilized for all students in the inclusion classroom. Goldstein (2004) described a collaborative teaching situation at the middle school level, and stated that shared planning time is "an essential part of making the system work" (p. 48).

Collaboration with Respect to Middle School Instruction

Collaborative planning is a common feature of the middle grades educational structure. According to Crow and Pounder (2000), "the only well-recognized example [of] collaborative work in education…may be found in middle schools" (p. 217). In a study conducted by Warren and Payne (1997), middle school interdisciplinary teams who had a common planning time reported higher levels of teacher efficacy and more positive perceptions of working environments than those who did not have common planning time or those who were departmentalized. In fact, the researchers cited numerous middle school experts who determined that the effectiveness of interdisciplinary teams may be most closely correlated with common planning times for the teachers on the team. They concluded that collaborative planning is essential to interdisciplinary teaming because it allows the teachers time to discuss the developmental needs of the students and thus provide developmentally appropriate instructional activities. Warren and Payne recommended that the presence of a common planning time has great potential to improve teaching efficacy and that it should be implemented in elementary and secondary grades.

Collinson and Cook (2000) studied collaborative planning at the middle school level and drew conclusions about teachers' perceptions of time. The teachers responded that they needed more common time to share ideas. The researcher's recommendations were that increasing individual and common study times for all teachers would be beneficial. The teachers who had the most common time benefited from the most sustained amount of sharing. Finally, a common sharing time as well as a common purpose resulted in increased teacher sharing.

Rutherford and Broughton (2000) established that a collaborative environment was a feature of high-performing middle schools when they compared low-performing schools to high-performing schools. The teachers at the high-performing schools listed collaboration and/or planning time as part of responses to the questions about desired changes, strengths of the school, and weaknesses of the school. Twenty-nine percent of the respondents expressed the need for improved staff relationships and 14% wanted more planning time. Eighteen percent of the respondents believed that lack of collaboration was a problem in their school, but 29% believed that collaboration was a strength. On the other hand, the teachers at the low-performing schools did not list planning time, collaboration, or lack of collaboration at all, suggesting that the issues may not be relevant to the respondents in these schools.

Conley, Fauske, and Pounder (2004) investigated factors that contribute to work group effectiveness with a sample of middle school teachers who worked in teams. The evidence from their study also supported collaborative practices. They concluded that the teachers generally perceived their teams as moderately effective with respect to teaching and learning; however, the sample reported a time related area of concern. Most inservice training occurred in brief infrequent sessions while the teachers preferred ongoing consultation with resources. In addition, the researchers determined that ongoing consultation, which exemplifies collaboration, as opposed to a one time training session was a significant predictor of perceived team effectiveness. A final observation by Conley et al. was that not only was a common planning time necessary to positively predict perceived group effectiveness, but also a balanced input from the participants was necessary.

Kams (2006) described strategies to teach successfully in an urban middle school, among which is collaboration. She served as a coach to the school which was part of a program called the Comprehensive School Reform program. Kams and the faculty she coached studied and reflected on teachers whose students scored well on the state achievement tests and determined factors that contributed to high test scores. One finding of the study concluded that successful middle school teachers must value planning and collaboration and collaborate with colleagues to ensure that standards are met. In addition, teachers that take the time to plan well are able to motivate the students and connect the content to student interests.

Collaboration with Respect to Block Scheduling

Teacher collaboration is also a common aspect of schools that use block scheduling. Salvaterra and Adams (1995) concluded that a connection existed between teacher collaboration and block scheduling. They determined that teachers who adapted well to block scheduling very often collaborated with colleagues to address challenges. Hackman (1995) encouraged teachers who had recently changed to a block schedule to collaborate on lesson development.

Quinn (1998) completed a case study of how block scheduling affected high school teachers' use of varied instructional techniques. Her findings illustrated the importance of collaboration and planning time for teachers. Prior to implementation of the new scheduling system, the faculty were required to complete intensive staff development on planning time and colleague collaboration. Those aspects of the staff development were rated higher by the teachers than training in specific instructional methods. Quinn also surmised that "with less courses to teach per semester, teachers should be able to devote more time to planning lessons which utilize a variety of instructional methodologies and thus impact student achievement" (p. 6).

Banbury (1998) also studied the affect of block scheduling on instructional practices at the high school level. He concurred with Quinn (1998) that block scheduling allows for a longer uninterrupted planning time which may lead to better teaching practices and higher student achievement. The teachers in Banbury's study rated planning time and collaboration with colleagues as more important means to improve their instructional techniques than training sessions. Banbury then recommended that teachers meet with departmental colleagues to determine what instructional changes needed to be made within the content area and then again to reflect on the implementations.

Holschen (2000) studied the impact of block scheduling specifically on high school mathematics instruction. He stated that adequate individual, departmental, and cross-curricular planning time was essential before and during the school year. He also agreed with Quinn (1998) that block scheduling allowed teachers to have fewer courses to prepare for and thus they could spend more planning time per course. Findings of Holschen's study were that 100% of the teachers from one school agreed that they had more planning time, but 100% also agreed that the extra time was necessary to develop more effective plans for the longer class period. Furthermore, the teachers perceived that since they planned more, their lessons were of higher quality. Finally, the teachers in Holschen's study believed they could teach math better in a block schedule than in a traditional schedule because they focused on using a variety of student-centered instructional activities.

Pruitt (1999) described evidence for the support of collaborative planning by explaining the positions of several national organizations. The National Commission on Time and Learning (NCTL), the National Council of Teachers of Mathematics (NCTM), the Association for Supervision and Curriculum Development (ASCD), and the National Association of Secondary School Principals (NASSP) all recommended changes in high school scheduling of classes. Teachers in her study indicated that the extended planning time had been advantageous in the development of departmental planning, co-teaching, teacher-to-teacher talk, and blended instruction. On the other hand, some of the teachers expressed concern that there was not enough time for collaboration with other teachers to learn new instructional techniques.

Collaboration as a Way to Improve Achievement

Many researchers believe that teacher collaboration is a means to increase student achievement. Corbin (1995) studied third grade students and their achievement across two types of teacher planning schemes: collaborative and non-collaborative. Findings indicated that collaborative planning by the teachers significantly improved students' scores on the Iowa Test of Basic Skills for Mathematics. In addition, Lick (2000) recommended whole-faculty study groups in order to improve learning opportunities for students and themselves. The study groups facilitated teacher reflection, experimentation, and motivation. He described a two-year middle school initiative in which the teachers formed study groups in an effort to improve teaching and learning in the school. The teachers met for two weeks in the summer to receive training in different models of teaching such as concept attainment and cooperative learning. During the school year, they met for an hour each week in their study groups to plan and practice lessons using the teaching models as well as reflect on videotapes of their teaching. Throughout the two years, the only changes in teaching were the study group training. As a result of the collaborative study groups and implementation of the teaching models, achievement in the school had improved. The percentage of students that reached promotion standards rose from 34% to 94%. In addition, the students' writing skills earned them third place in the district rather than eleventh place as in the previous year.

Hair, Kraft, and Allen (2001) studied staff development in high-performing, high-poverty Louisiana schools. The researchers reported that despite the approaches were taken, all faculty involved were expected “to grow and learn collaboratively with their professional colleagues” (p. 6). An example can be found in one of the schools where the faculty met at school on Sunday afternoons to plan weekly lessons and share ideas. Collaboration is also exemplified by a school in which the faculty rotate through the classrooms of one grade level per month to learn and share successful instructional strategies. Another practice found at the high-performing schools discussed in the report was a commitment of time to data analysis and subsequent instructional planning. Hair et al. (2001) concluded that faculty collaboration was “critical to improve practice” (p. 9).

Caron and McLaughlin (2002) examined six Beacons of Evidence Schools, as designated by the U.S. Department of Education, who were achieving academic excellence for all students in order to determine indicators of school success. The results from their study paralleled those of Hair et al. (2001). The most dominant feature of the Beacon schools was the sense of a collaborative community. In fact, general and special educators at these schools exhibited a culture of shared responsibility and collaboration. Specifically, five of the six schools showed evidence of collaborative planning, especially at the beginning of each grading period or before a new unit of instruction. Collaborative planning occurred among general and special educators and among grade level educators.

Picucci, Brownson, Kahlert, and Sobel (2002) completed a study that also reinforced evidence provided by Hair et al. (2001) and Caron and McLaughlin (2002). They examined seven high-performing, high-poverty middle schools. They determined that the schools had extensive collaborative networks within the schools, the districts, and with outside entities. Grade level teachers had common planning times in all of the schools in which instructional and developmental issues were discussed. Five of the seven schools utilized some form of block scheduling. Teacher responses indicated that the common planning time allowed for the sharing of ideas and integration of the curriculum and that the extra planning time afforded by the intensified schedule was beneficial. Picucci et al. described an example of how collaborative planning impacted achievement. A language arts teacher noticed the need for a common instructional approach to essay writing. He developed a method, introduced it to colleagues, modeled it for colleagues, and observed colleagues who were implementing the method. As a result of the collaboration, the writing abilities of the students improved so much that both the elementary and high school began utilizing the same writing approach. Based on the findings from their study, the researchers recommended that schools enact common planning times and/or departmental meetings and provide training in how to effectively use collaborative time.

Trimble's (2002) findings concurred with Picucci et al. (2002). She studied high-achieving, high-poverty middle schools from 1997 to 2000 and determined that a common characteristic was the existence of teams of teachers and administrators. The schools all had common planning times as part of their schedules. Some of the schools utilized study teams which corroborates Lick's (2000) findings. The study groups brainstormed instructional ideas, tried them for two weeks, and reconvened to discuss their findings. Trimble concluded that the study groups facilitated "sustained changes in instructional practice" (p. 13).

A group of researchers from the Appalachia Educational Laboratory at Edvantia (Craig et al., 2005) investigated common characteristics of high performing schools in Tennessee that have high percentages of low socio-economic status (SES) students and minorities. One key component of the high achieving schools was the presence of a collaborative democratic school culture (Hair et al., 2001; Kannapel & Clements, 2005; Picucci et al., 2002; Trimble, 2002). The Edvantia researchers interviewed teachers and principals at the six schools as well as administered five survey instruments. The interviews showed that teacher collaboration with administrative support was a common feature of the schools. The administrators supported collaboration by providing time for departmental meetings and/or common grade level planning times. In addition, the interviews indicated that the faculty collaborates in developing goals and action plans for school improvement.

Collaboration as a Way to Improve Instruction

Not only can teacher collaboration improve achievement, but it has also been shown to improve instruction. Goodlad (1984) believed there was no infrastructure to encourage communication among teachers to improve their teaching or solve work place problems. A 1986 report by the Holmes Group reported that teachers still have little time to work with other teachers in order to improve their knowledge and skills. Glatthorn (1993) offered several recommendations about teacher collaboration. He urged that teachers work in grade level or subject teams to develop instructional units, which he thought were the best means to emphasize problem solving and critical thinking. Furthermore, he recommended that experienced teachers mentor novice teachers and help them to write detailed lesson plans. However, he recommended that experienced teachers not be required to turn in plan books but collaboratively plan in order to improve the quality of the lesson.

Adajian (1996) studied high school mathematics teachers and the relationship between their professional communities and instruction. Findings indicated that teachers who collaborated with other teachers used higher levels of reformed mathematics instruction, and it is a strong recommendation of the NCTM that math teachers reform mathematics instruction. Warren and Payne (1997) studied teams of teachers at the middle school level; one team had a common planning time, while the other team did not. They determined that the teachers who had a common planning time reported significantly higher perceptions of teacher efficacy, instructional coordination, and collaboration and significantly higher work place satisfaction and commitment than those who did not have common planning times.

Lesson improvement is also supported in studies by Corrick and Ames (2000) and Welch (2000). Corrick and Ames described a successful program in which library media specialists (LMS) collaborated with content area teachers in order to better prepare lessons for the students. The LMS helps to plan the lesson, teach the lesson, and even assess the students' work. Welch (2000) studied two teams of teachers at the elementary school level. He determined that the team who had a longer planning time utilized a greater variety of team-teaching strategies than the other team. High school teachers in South Dakota reported that collaboration occurred as the result of mentoring programs and was an effective way to share ideas and materials (Barnett, 2004).

Findings of Conley et al. (2004) concurred with a collaborative model developed by Hackman and Oldham in the 1980s. The findings showed that healthy interpersonal process factors affect knowledge, skills, and appropriateness of strategies applied to group tasks. Taylor (2004) directly studied the impact of collaborative planning on the quality of lesson plans. The quality of the lesson plans was determined by an instrument called the Student Teacher Assessment Instrument (STAI). Taylor's findings showed evidence that a significant positive correlation existed between collaboration and lesson plans that received higher scores on the STAI. Taylor proceeded to describe the lesson plans with higher STAI scores as "potentially more effective than those that fail to receive such scores" (p. 44). Recommendations of the researcher included that principals schedule time for group/grade level/departmental joint lesson planning sessions and that teacher preparation programs include methods of collaboration as part of their training.

Improving Collaboration

Collinson and Cook (2000) asserted that common planning time positively affected sustained teacher sharing, especially when coupled with a common purpose. Administrators may be able to schedule common planning time or provide coverage for classes so that teachers may meet with each other. In addition, flexible instructional time will increase time for sharing. For example, the elementary school that Decker (2000) investigated scheduled longer instructional days on Tuesday through Friday, but offered two hours of uninterrupted planning time to teachers on Monday. The teachers favored this scheduling decision because they perceived that the time would assist them with effective teaching.

Block scheduling is another mechanism that has created longer planning times for teachers (Banbury, 1998; Canady & Rettig, 1995; Hackman, 1995; Holschen, 2000; Pruitt, 1999; Quinn, 1998; Salvaterra & Adams, 1995). Some school districts that utilize block scheduling require collaborative planning among teachers.

Caron and McLaughlin (2002) concurred with the findings of other researchers; necessary supports for collaboration include time and technology-based communication systems. They recommended that time is needed for teachers to spend in each other's classrooms, co-teach or co-plan, and attend professional development activities together. The principals in Caron and McLaughlin's study provided coverage by aides, volunteers, or substitutes in order for the teachers to have time to meet.

Obstacles to Collaboration

While collaboration is recommended by many researchers and educational organizations, there are many obstacles to implementing it effectively. First of all, logistically, collaboration may be difficult to implement. Doyle and Ponder (1977) described prohibitory conditions to innovations, among them availability of space and time required to integrate the innovation as well as the cost of investment versus the amount of expected return. It may be difficult to schedule a common time when teachers may plan together, or there may be no money to pay for a substitute teacher so that the regular teachers may have release time to plan together. O'Neal and Cox (2002) described weaknesses in small rural schools. One weakness was frequent isolation from same-field colleagues. The isolation occurred because either there was only one teacher per field in the school or the entire faculty was overworked to maintain necessary school functions. Bauwens, Hourcade, and Friend (1989) concurred that if teachers perceive the cost of educational innovation as time or energy consuming, then they are less likely to support the innovation. They recommended that during the initial implementation of cooperative teaching, scheduled planning was essential; however, after the initial lessons were developed, less planning time was needed. They recommended that principals schedule common planning times or give release time so that teachers could plan together.

The trend in teacher learning experiences may also be an obstacle to collaboration. Clarke (1994) and Wood and Thompson (1980) determined that teacher learning experiences occur infrequently, in non-classroom settings, provide little active involvement, and provide little follow-up. Furthermore, Wood and Thompson recommended that inservice sessions align with research about adult learners: topics must be relevant to personal and professional needs, feedback is necessary for the adults to see the results of their efforts, the participants must be involved in selecting objectives/activities/assessment of the sessions, and the setting must be naturalistic and full of social interaction. Smylie (1989) concluded, after studying the results of a National Education Association survey, that teachers perceived techniques associated with direct experience in the classroom as the most effective sources of learning. The techniques specifically mentioned by teachers in the survey were consultations with and observations of fellow teachers, techniques that were seldom employed by inservice sessions. Smylie's results concurred with Zahorik's (1987) who determined that the teachers in his study perceived interaction with colleagues as more useful than university classes, professional journals, or inservice sessions. Fullan (1990) determined that effective staff development was present in schools that promoted the idea of "teacher as learner" (p. 18). These teachers had characteristics of being reflective and collaborative. The literature supports ongoing training and feedback as more effective than one time inservice sessions (Conley et al., 2004).

A third very influential impediment to collaboration is the pervasive view that traditional teaching methods are more effective than reform methods. Many school systems as well as teachers still endorse a traditional teacher-centered classroom with didactic instruction. Hargreaves (1993) challenged teachers and schools to encourage cooperative classrooms and collaborative staffrooms that are spontaneous and unpredictable rather than characterized by "contrived collegiality" (p. 102). He also urged teachers to become more reflective, to redefine their fundamental purpose, and to forge connections between work and personal lives to become better assimilated into the postmodern era. Preservice teacher education programs still prepare teachers as they have for decades (Cooper, 1996; Shulman, 1987). Shulman described teacher education as reform oriented in areas such as admissions standards, new competency exams, and longer programs; however, he also asserted that the "content-free domains of pedagogy and supervision" must no longer be emphasized (p. 20). Instead, the proper knowledge base, sources of the knowledge, and content pedagogical processes are a necessary part of preparing teachers. Cooper (1996) contended that teacher education programs must shift from teacher-directed instruction to a conceptually based approach in order to model the recommended approaches to teaching children. She compared a university-based methods course for preservice mathematics teachers to a field-based course. She concluded that the field-based teacher focused on teacher behavior, student behavior, and the development of concepts. On the other hand, the university-based teacher focused on use of manipulatives and activities and self-reflections. Cooper asserted that the university-based teacher did not have ample time to observe students' behavior, and urged that university instructors and cooperating teachers collaborate to prepare teachers effectively.

Finally, current reform efforts involve many areas such as curriculum design, instructional techniques, professional development, school governance, and assessment (Wickstrom, 1995). Teachers may not be able to focus on collaboration if there are other reform areas that may be mandated; they do not have enough time to adequately address all reform areas that are recommended. For example, the NCTM developed three standards books in the 1990s. The books involved curriculum and evaluation standards, professional teaching standards, and assessment standards; three very different areas of reform.

Welch (1998) categorized the obstacles to collaboration as: (a) conceptual, (b) pragmatic, (c) attitudinal, and (d) professional. Welch’s conceptual and attitudinal barriers corresponded to Hargreaves’ findings that some teachers prefer modern and traditional methods of instruction while the professional barriers correspond to Clarke’s (1994), Wood’s and Thompson’s (1980), Smylie’s (1989), and Zahorik’s (1987) findings regarding sustained training in collaboration. Pragmatic barriers include those as described by Doyle and Ponder (1977) and Bauwens et al. (1989) such as time, space, or funds.

Factors That Affect Planning

Instructional planning is affected by many factors. Teachers plan based on the content and instructional techniques they know. The curriculum goals of the state, district, and school must also be considered in the planning process. Finally, other ancillary factors impact planning strategies such as materials, teacher isolation, classroom management skills, use of the Internet, grade and experience levels of the teacher, and time.

Materials

Availability of materials has an effect on instructional planning. Zahorik's (1975) study concluded that 56% of the teachers studied made planning decisions about materials; however only 3% made the decision about materials first in the planning process. The textbook has been the major source of ideas that were developed into lesson plans from as early as McCutcheon's study in 1980 to present day. McCutcheon concluded that the teachers in her study exhibited a heavy reliance on textbooks for instructional planning, especially in reading and mathematics. In addition, McCutcheon believed that this emphasis on textbooks and teacher's guides led to a disjointed curriculum. Finally, the teachers in McCutcheon's study reported that availability of materials and shortcomings in the textbooks resulted in problems during instructional planning.

The sample of teachers in Erickson's (1993) study concurred with McCutcheon's (1980) regarding the lack of materials. Ironically, the teachers in Sardo-Brown's (1990) study reported that textbooks were among the least influential factors of planning; yet they also reported that books were among the most frequently consulted sources. An's (2001) findings were consistent with Sardo-Brown's. Her study of Chinese and American middle school teachers reported that only 19% of the U.S. teachers planned for instruction by using the textbook, whereas 81% of the Chinese teachers focused on the textbook.

Teacher Isolation

Another factor that influences planning is teacher isolation. Teacher isolation resulted in a lack of opportunity for teachers to raise issues. The teachers reported that they did get ideas from inservices and education journals; however, there was a "lack of access to a variety of teachers with fresh ideas and outlooks (McCutcheon, 1980, p. 13). Bullough (1987) investigated the planning practices of a new seventh grade teacher and found that she perceived she was responsible for planning without any help from the more experienced teachers. She did not perceive planning as problem-solving or collaborative. Her isolation as a new teacher negatively impacted her effectiveness as a teacher.

Sardo-Brown (1990) reported that teachers in her study routinely consulted other teachers and ranked them as fairly influential to their planning habits. On the other hand, Erickson (1993) reported that the middle school teachers she investigated cited lack of collaboration with peers as an impediment to effectively teaching mathematics. Rizor (2000) studied elementary teachers to record baseline information on instruction as the schools prepared to implement state standards and testing in mathematics. The teachers in the study indicated that they were seldom able to meet with other teachers to discuss instruction. Finally, Rettig, McCullough, Santos, and Watson (2003) described the culture of teaching as "isolated" (p. 74) and suggested meaningful support as a mechanism to improve student achievement.

Classroom Management Skills

A third factor that may influence instructional planning is the classroom management skills of the teacher. The teacher in Bullough's (1987) case study planned only for curricular instruction before she began her new job. By, the third week of school, however, she determined that planning for classroom management was also a necessary part of teaching. Planning for classroom management included establishing order as well as routines. Bullough also concluded that teachers who have ineffective classroom management skills may avoid planning for risky or fun activities, instead planning for activities that facilitate teacher control of the students.

Other researchers reported on teachers' perceived need to plan in order to positively influence classroom management. Kagan and Tippins (1992) concluded that the need to control students influenced secondary novice teachers to write extremely scripted lesson plans for lessons that were essentially lectures. The researchers also asserted that although classroom management is important, lesson plans may need to be written as a list of instructional procedures in order to reduce the number of lessons taught by the information-giving model in which students passively receive facts.

Housner and Griffey (1985) contended that experienced teachers make considerably more planning decisions than novices do in the area of behavior management. Fogarty, Wang, and Creek (1983) agreed by finding that experienced teachers could attend to a number of classroom cues as well as easily consider goals of student motivation. Doyle (1986) determined that successful teaching has two components: learning and order. Order is a necessary component of teaching and takes place with managerial planning. Thus, planning for classroom management is a necessary part of teaching.

Use of Internet as Resource

Technology as an aid in lesson planning began in the 1980s with the Computer-Prompted Instructional Planning System and Lesson Plan Maker. Currently the Internet is a vast source of information that may be incorporated into lesson plans and shared with other teachers without the bounds of time and space (Lin & Wang, 2002). A German study investigated how teachers prepare lessons conventionally as compared to planning with use of the Internet. The study confirmed that teachers look for materials that easily can be integrated into new or existing lessons, a process similar to berrypicking as described by Small et al. (1998). In addition, teachers look to the Internet for readily accessible quality materials that are motivational to students. Teachers in the study wanted quick and direct guidance to free materials for specific topics and age levels. The researchers recommended money allocated for educational purposes be spent on developing an Internet infrastructure of teaching materials (Hedtke, Kahlert, & Schwier, 2001).

Teachers in the United States also sought such an Internet education database. By 1998, thousands of educational materials existed on the Internet, but not with user-friendly retrieval methods. Small et al. (1998), in a project funded by The U.S. Department of Education, studied the Internet-searching patterns of prekindergarten to 12th grade teachers. Results of the study indicated that out of the available educational resources on the Internet, 76% were lesson plans, 23% were unit plans, and 1% were activities. In addition, the most frequently requested quantifiers were subject area, grade range, and topic. Furthermore, respondents reported that they created lesson plans based on their findings from various resources and that they relied on established routines for finding online materials. Finally, the findings indicated that sometimes the teachers searched for information other than that pertaining to their own classroom such as topics like inclusion (Small et al., 1998). The researchers recommended an all inclusive educational database with universal identifiers that make searching easy.

Internet databases are available nationwide and even worldwide. They are also specific to regional or state educational entities. Lin and Wang (2002) described a Web-based lesson planning system under development at the time in Missouri. The capabilities of the system were to align lessons with Missouri standards, preserve and facilitate sharing of lesson plans among Missouri teachers, and promote improved lesson plans via collaboration among teachers and with parents.

The Internet offers many choices of educational sites with ideas for lessons and activities. Dyrli (2007) developed a guide for Internet "curriculum hotspots" (p. 33). The guide includes search tools, lesson plan collections, research sites, curriculum centers for all subject areas, online projects, and professional resources. Although the number of online websites for lesson plans is abundant, Hughes (2005) cautioned that such lesson plans must be evaluated with a critical investigation to ensure that the lesson meets the needs of all the learners.

Grade Level

Grade level is another factor that influences planning. Wendel (1990) determined that the secondary teachers in his longitudinal study planned primarily for content and when to give tests. On the other hand, they planned little for teaching strategies, teaching style, and evaluation other than tests or quizzes. Kagan and Tippins (1992) concurred with Wendel that elementary and secondary teachers plan differently. The elementary teachers in their study used lesson plans to organize their thoughts and materials; however, the plans were rarely used during the actual lesson. In addition, as the year progressed, their plans grew less detailed. Conversely, the secondary teachers in the study used lesson plans as memory aids, and as the semester passed, their plans became more detailed and scripted. Moreover, the elementary teachers focused on learning activities and methods of connecting lessons to many subject areas. In contrast, the secondary teachers focused on delivering the content of the subject, maintaining control of the class, and evaluating the students with written tests. Ornstein (1997) asserted that generally elementary teachers developed lessons around activities, whereas, secondary teachers developed lessons around topics or questions.

Experience Level

Research has shown that novice teachers and experienced teachers plan lessons differently. Glatthorn (1993) recommended that new teachers plan in a very structured detailed format, and that they consult with mentor teachers at least weekly. On the other hand, experienced teachers may not need to submit weekly lesson plans although they should participate in on-going staff development on planning topics and should plan collaboratively.

Lederman and Niess (2000) also discussed the differences between new teachers and experienced ones when they described that new teachers questioned why they had to write detailed plans while their mentors only had to fill two by two boxes. They recommended, as did Glatthorn (1993), that experienced teachers did not need to write detailed plans; however, the experienced teachers should communicate on a regular basis to their mentees that the type and degree of planning does differ from new teachers to experienced ones.

Fogarty et al. (1983) also compared the planning activities of novice teachers to experienced teachers. They observed that experienced teachers utilized twice as many kinds of instructional actions, regarded a greater variety of goals, and demonstrated more complex relationships between cue and action categories.

In addition, Housner and Griffey (1985) provided evidence of numerous differences in the planning actions of beginning versus experienced teachers. First of all, during planning, experienced teachers made more decisions about instructional activities than did inexperienced teachers. While sufficient planning time is important, Housner and Griffey determined that experienced teachers planned lessons more efficiently, requiring an average of 22.48 minutes per lesson as compared to novice teachers who required 47.32 minutes per lesson.

Finally, McCutcheon (1980) and Sardo-Brown (1990) concurred with Housner and Griffey (1985) by asserting that experienced teachers drew heavily on prior experiences when making instructional decisions. On the other hand, Kagan and Tippins (1992) did not find differences in planning with respect to experience. They determined that both novice and experienced teachers used a lot of mental planning with only small amounts of written plans; more detailed plans were used on rare occasions such as for planning a new unit.

Time

A final factor that influences instructional planning is time. Time has been an issue in education for several years. McCutcheon's (1980) sample of teachers reported that limited planning time forced them to pursue their initial instructional ideas rather than consider any alternative techniques. Teachers in Erickson's (1993) study cited short preparation times as an impediment to implementing ideal instructional methods that impart standards-based education. Glatthorn (1993) asserted that good unit plans are time consuming but well worth the time and effort. A 1993 RAND study determined that it takes at least 50 hours of instruction and practice for teachers to become comfortable with a new instructional technique (Alperin, 2001). Robbins (1993), in testimony before the National Education Commission on Time and Learning (NECTL), contended that teachers need more quality time for planning because of their presence before an increasingly diverse student population. The NECTL then published a report called Prisoners of Time in 1994 that declared time as critical to education reform efforts in the United States (Viale, 2005). Teachers from the GOALS 2000 Teachers Forum concluded that there is a direct correlation between planning time and instructional quality and stated that "increased planning time for teachers is more important for improving instruction than increasing instructional time with students" (Livingston, 1994, p. 8).

Recent studies in the 2000s also support extending planning times for teachers. Alperin's (2001) thesis focused on teacher's attitudes toward increasing planning time. Her sample of teachers almost unanimously believed that sufficient planning time was necessary to successfully implement new curriculum and raise student achievement. Decker (2000), Wolf (2003), and Viale (2005) agreed with Alperin that the teachers in their studies preferred to have more planning time, especially instructional planning. The teachers in Wolf's sample reported that they completed about 20% of their work at home and an average of 5 hours per weekend on schoolwork. Although they were willing to work at home, they believed more planning time at school would be beneficial. Viale's sample reported that they would benefit from an increase in independent daily planning time; in fact, less than 10% of the sample reported sufficient planning time to implement standards-based instruction. All of Decker's sample reported that they were frustrated and dissatisfied with their schedule of planning time. They felt that time was a "major constraint on what they are able and expected to achieve in their schools" (p. 24).

Research also shows that U.S. teachers spend less time planning than do their counterparts in other countries. Adelman (1998) determined that the school day in Germany and Japan was shorter than that in the United States, thereby allowing teachers more time to plan. In addition, the planning time occurred in longer blocks of time than in the United States so the teachers were able to think and reflect on previous and upcoming lessons. An (2001) compared planning times of American and Chinese middle school teachers. A majority of the U.S. teachers planned for instruction less than 30 minutes daily (44%) or perhaps an hour daily (30%) while about half of the Chinese teachers planned for instruction an hour daily and 34% planned for two hours daily. Many U.S. teachers teach five periods of 45 minutes daily or three periods of 90 minutes daily, one of which is a planning period. On the other hand, the Chinese teachers teach two periods of 45 minutes daily, while the rest of the day is spent in lesson planning or grading of work. According to The Third International Mathematics and Science Study (TIMSS) in the 1990s, the 8^{th} grade curriculum in the United States was a full year behind that of other higher achieving nations (Maccini & Gagnon, 2000). U.S. eighth and twelfth graders scored below average in mathematics compared to the other nations in the assessment (Silver, 1998). Sparks (1994) concurred with An's conclusion that U.S.

teachers spend more time in direct instruction with students than do the teachers in China, Japan, and Germany. The larger portion of time spent in instruction resulted in less planning time.

The literature supports adequate planning time and collaborative planning as prerequisites to effective teaching (An, 2001; Burns & Reis, 1991; Decker, 2000; Glatthorn, 1993; Misulis, 1997; Ornstein, 1997; Panasuk et al., 2002; Welch, 2000; Wolf, 2003; Yinger, 1980). Longer planning time is associated with a student-centered instructional approach (An, 2001), promotion of thinking skills (Burns & Reis, 1991), and use of a greater variety of instructional strategies (Welch, 2000). Longer planning time is also beneficial for teachers because it offers time for reflection, collaboration, and continued learning opportunities (D'Amrosio et al., 2004; Simon, 1992). Furthermore, current national standards endorse the importance of planning (Blank, 2004; NBPTS, 2000; Peterson & Bond, 2004, Principles and Standards, 2000).

Collinson and Cook (2000) concluded that the five largest barriers to teacher sharing were all features of time. Adelman (1998) asserted that longer planning times of more than 30 minutes have the potential for teachers to substantially better plan whether individually or collaboratively. Viale (2005) concluded that current models of planning time impede effective implementation of academic standards. If Viale's conclusions are accurate then perhaps longer amounts of individual and collaborative planning time will improve efforts to implement academic standards such as those recommended by the NCTM.

The NCTM Standards

The NCTM is recognized as having been the first professional content organization to develop a set of national standards for education (Russ, 1992). The organization defines standards as criteria for excellence in school mathematics programs. The purpose of the NCTM standards is to guide mathematics educators and supervisors in developing programs to meet their individual needs (Lappan, 1999a). The standards resulted from decades of low performance by students in math and science following a period of alternating educational trends dating back to the early 1900s. The implementation of the standards brought changes in mathematics education that affected the level of performance of U.S. students. The standards also have implications for the future of mathematics education.

The U.S. Educational System Before and After the Standards

In 1920, the NCTM was formed to provide national leadership in mathematics education and is now the world's largest mathematics organization with over 100,000 members in the United States and Canada (NCTM, At a Glance, n.d.). Its mission was to provide teachers with the skills necessary to ensure the highest quality mathematics education to all students (NCTM, Mission, n.d.). An early math reform movement was sparked in 1957 when Russia launched Sputnik into outer space. As a result of reform efforts, the NCTM developed a set of recommendations for secondary school mathematics in 1959 (Klein, 2003). Subsequently, several experimental programs were designed to improve computational and problem-solving abilities of U.S. students (Souviney, 1989).

However, by the 1970s and 1980s, many students did not take math after the first years of high school and math achievement levels began to decrease again reaching their lowest scores in the 1980's (Burrill, 1997; Burrill, 1998; Klein, 2003). In 1980, the NCTM published An Agenda for Action which proposed major reform in mathematics education (Willoughby, 1988). An Agenda for Action and A Nation at Risk (1983) were both reports that served as catalysts for developing national standards (Burrill, 1997; Klein, 2003; Martin & Berk, 2001; Roitman, 1998; Romberg, 1993). The reports recommended emphasizing problem-solving even though basic skills may not have been mastered yet. Technology would assist low performers in completing problem-solving exercises. In addition, use of group work, manipulatives, and multiple measures other than testing were emphasized by the NCTM (Klein, 2003). National standards were a focus of President George Bush's strategy for school reform and were adopted by the National Education Goals Panel (Romberg, 1993).

As a result of these factors, in 1986 the NCTM began developing a set of national standards. Composed of teachers, supervisors, mathematicians, and mathematics educators, the Commission on Standards for School Mathematics, prepared a draft document (Burrill, 1997). Suggestions from over 2000 respondents were considered, and the re-written document was published in 1989 as the Curriculum and Evaluation Standards for School Mathematics. The Professional Standards for Teaching Mathematics and Assessment Standards for School Mathematics would eventually be written and the collective set called the *Standards* (Burrill, 1997; Klein, 2003; Martin & Berk, 2001; Roitman, 1998; Romberg, 1993; Russ, 1992).

The *Curriculum Standards* (1989) described the learning of mathematics as not necessarily linear, and viewed many mathematical concepts as important regardless of whether more basic material had been mastered (Burrill, 1997; Willoughby, 1988). The *Curriculum Standards* also stated that all children could learn mathematics and should become actively involved in the learning of mathematics (Willoughby, 1988). The *Teaching Standards* (1991) encouraged experimentation with a variety of lesson designs and implementations to help students engage in and understand mathematics (Burrill, 1997). Suggested strategies included use of cooperative learning, use of evidence to verify results, use of conjecturing, inventing, and problem solving rather than mechanical computations, and use of real life situations to make connections from mathematics to other areas (Schroeder, 1991). Other traditional methods of instruction such as drill and practice with pencil-and-paper, memorization of rules and algorithms, and note-taking from lectures were de-emphasized (Klein, 2003; NCTM, 1995). The *Assessment Standards* (1995) advocated high expectations for all students using assessments gathered from multiple sources. In addition, although teachers were the primary assessors, the students should learn to assess their own progress (NCTM, 1995). Overall, the standards described a universal philosophy and approach for teaching mathematics as well as a suggested content of math classes (Jackson, 1997). More specifically, the standards were guided by constructivism, a theory in which students build their own knowledge base through active participation in the learning process and by connecting new knowledge to existing knowledge (D'Ambrosio et al., 2004).

The *Standards* had several implications for mathematics education. Before the *Standards*, mathematics was regarded as a body of facts and procedures to be mastered

(Pape & Smith, 2002). The *Standards* encouraged understanding and problem solving over rote practice and procedures and active learning over transmission of information by teachers. The Standards explained that learning math did not mean memorizing and repeating, but rather investigating, conjecturing, reasoning, and reflecting. In addition, learning algebra, geometry, statistics, and even calculus was encouraged (Romberg, 1993). Traditional teaching methods were de-emphasized while reform methods were emphasized (Klein, 2003; NCTM, 1995).

Many mathematics teachers appreciated the guidelines for content, instruction, professional development, and assessment techniques. Higher education mathematics professors favored the *Standards* because they resembled some of the calculus reform projects that were taking place (Jackson, 1997).

Positive effects of the *Standards* included a large membership increase, an increase in Eisenhower and NSF funding of projects to develop new instructional materials, and substantial changes in textbooks (Burrill, 1997; Martin & Berk, 2001; Reyes & Robinson, 1999; Romberg, 1993). By 1997, 46 states had created their own mathematics standards and aligned them with those of the NCTM (Burrill, 1997; Martin & Berk, 2001). The needs of the business community influenced the creation of The Standards, and the role of business in American education was increasing. Research groups included businessmen, math practitioners, math teachers, and education specialists (Roitman, 1998).

Implementation of the *Standards* appeared to have increased national test scores, as well. The average SAT math score in 1997 was the highest since 1972. The 1996 scores on the National Assessment of Educational Progress (NAEP) test showed significant improvements from the 1990 scores (Burrill, 1998). Fourth graders scored above average on the Third International Mathematics and Science Study (TIMSS) (Burrill, 1998). Martinez and Martinez (1998) cited the improvements in NAEP scores and described increases in the number of high school students who took advanced math classes based on information from the National Center for Education Statistics. Improvements were seen with white students and also with all minority groups such as African Americans, Hispanics, and Native Americans. Research showed that schools with the highest level of reform scored above the state means on mathematics tests (Felner et al., 1997). The Core-Plus Mathematics Project (CPMP) published evidence that showed improvements in skills as a result of the *Standards*. The results of the study indicated that students using a curriculum based on the *Standards* significantly outperformed students in a control group on measures of problem solving and reasoning (Reyes & Robinson, 1999).

On the other hand, the *Standards* had some negatively perceived effects as well. One criticism of the document involved at-risk learners. Mercer and Harris (1993) cited that the *Standards* contained little effective instructional practices for at-risk learners. In fact, no references were made to the varying skill abilities of the students. Some thought concepts presented in the *Standards* were vague and open to many interpretations (Jackson, 1997; Mercer & Harris, 1993). Some teachers overenthusiastically jumped into the *Standards* without carefully implementing their suggestions. The result was an exciting style of teaching mathematics which, however, lacked a firm grounding in sound instructional practices (Oster, Graudgenett, McGlamery, & Top, 1999). Another problem with the *Standards* was that while they were widely read, actual implementation was slow to spread and evidence was not available to support their effectiveness (Martin & Berk, 2001). The TIMSS report from the early 1990s showed that the 8^{th} grade curriculum in the United States was a full year behind that of other higher achieving countries (Maccini & Gagnon, 2000; Martinez & Martinez, 1998). This same report showed that 61% of 8^{th} grade lesson plans were focused on skills, while only 22% focused on thinking skills (Burrill, 1998). TIMSS described the U.S. curriculum as wide and very shallow, and the Second International Mathematics Study (SIMS) described it as underachieving (Lappan, 1999b). Even though the NAEP test showed gains, The *Standards* came under fire concerning preparation for standardized tests (Oster et al., 1999).

Standards 2000

By the mid-1990s, the NCTM began a process to refine the *Standards* which was published in April 2000 as *Principles and Standards* (NCTM, 2000). The NCTM believed that a combination of the three documents would provide a more coherent vision for mathematics education (Jackson, 1997).

Principles and Standards has several features not present in the original documents. First, the grade bands changed from K-4, 5-8, and 9-12 to pre-K-2, 3-5, 6-8, and 9-12. Recent research shows the importance of a good mathematics foundation at early ages so pre-kindergarten is now included in the guidelines. In addition, the new standards contain principles as well as standards (Lappan, 1999a). The six principles for school mathematics are equity, curriculum, teaching, learning, assessment, and technology. The equity principle states that “excellence in mathematics education requires equity- high expectations and strong support for all students” (NCTM, 2000, p.

12). Essential to the equity principle is the provision of the human and material resources necessary to accommodate differences in student abilities.

The curriculum principle states that "a curriculum is more than a collection of activities: it must be coherent, focused on important mathematics, and well articulated across the grades" (NCTM, 2000, p. 14). Coherent refers to the ideas presented in mathematics as being interconnected not fragmented. Teachers at all grade levels should familiarize themselves with the mathematics at other levels in order to provide an interconnected and increasingly sophisticated depth of knowledge.

The teaching principle states that "effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (NCTM, 2000, p. 16). Imperative in the teaching principle is teachers that know their content, employ a variety of pedagogical approaches, and continually seek to improve themselves. In addition, teachers must provide a challenging but supportive environment.

The learning principle states that "students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge" (NCTM, 2000, p. 20). The NCTM believes that conceptual understanding must occur along with the acquisition of factual and procedural knowledge for true learning to take place.

The assessment principle states that "assessment should support the learning of important mathematics and furnish useful information to both teachers and students" (NCTM, 2000, p. 22). Assessment should enable the teacher to make instructional decisions and should be based on a variety of sources in order to yield an accurate picture of the student's ability.

The technology principle states that "technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000, p. 24). Technology is a powerful tool that allows students to focus on problem solving and making conjectures rather than to focus on computation. It may also aid students with special needs (NCTM, 2000).

Principles and Standards (2000) also contains two types of standards: content standards and process standards. The content standards include number and operations, Algebra, geometry, measurement, and data analysis and probability. The number and operations content area consists of ensuring that the students know how to represent numbers, number systems, and relationships among numbers. In addition, the area states that students understand the meanings of operations and can compute fluently for accuracy as well as estimation. The Algebra content area consists of several objectives. First, all mathematics students should understand patterns, relations, and functions. Next, they should be able to represent and analyze mathematical situations with some type of model such as symbols or manipulatives. Finally, students should be able to analyze change. The third NCTM content area is geometry. Geometry involves teaching students to analyze characteristics of two and three dimensional shapes and use visualization and spatial reasoning to describe and model relationships. The measurement component of the content standards ensures that students can understand measurable aspects of objects, types of measurement systems, and appropriately apply the tools and formulas to determine measurements. Finally, data analysis and probability are emphasized by the NCTM content standards. Students should be able to collect, organize, display, and interpret data and draw inferences based on data (NCTM, 2000).

The NCTM standards are so universal that many states align their mathematics educational goals with them. West Virginia's State Board of Education Policy 2520.2 defines the state's content standards and goals for public schools. The policy was developed by committees of educators from across the state. The standards are aligned directly with the NCTM content standards published in 2000. Although the policy does not specifically outline instructional methods, the NCTM process standards are reiterated throughout each grade's objectives. Furthermore, the process standards are emphasized in each content area of mathematics at the high school level (WVBOE, 2003). According to David Stewart, state superintendent of schools at the time of Policy 2520.2's implementation, "The content standards, objectives and performance descriptors combine to give teachers a powerful resource for planning instruction" (WVBOE, 2003, p. 3).

The Process Standards

This study focuses on the NCTM's process standards. The process standards describe ways that students should acquire and use content knowledge. They overlap and are integrated throughout all of the content standards. Problem solving is the first process standard. It involves several subcategories. All students should be able to: (a) build new mathematical knowledge through problem solving, (b) solve problems that arise in mathematics and in other contexts, (c) apply and adapt a variety of appropriate strategies to solve problems, and (d) monitor and reflect on the process of mathematical problem solving (NCTM, 2000, p. 52).

The second process standard consists of reasoning and proof abilities. Students with developed reasoning and proof skills are able to: (a) recognize reasoning and proof as fundamental aspects of mathematics, (b) make and investigate mathematical conjectures, (c) develop and evaluate mathematical proofs and arguments, and (d) select and use various types of reasoning and methods of proof (NCTM, 2000, p. 56).

The third process standard emphasizes communication skills. Students in mathematics classes should be able to: (a) organize and consolidate their mathematical thinking through communication, (b) communicate their mathematical thinking coherently and clearly to peers, teachers, and others, (c) analyze and evaluate the mathematical thinking and strategies of others, and (d) use the language of mathematics to express mathematical ideas precisely (NCTM, 2000, p. 60).

Another NCTM process standard is that of connections. Mathematics students should be exposed to connections by being taught to: (a) recognize and use connections among mathematical ideas, (b) understand how mathematical ideas interconnect and build on one another to produce a coherent whole, and (c) recognize and apply mathematics in contexts outside of mathematics (NCTM, 2000, p. 64).

The final process standard essential in the teaching of mathematics is that of representation. Representation involves several aspects. Students should be able to (a) create and use representations to organize, record, and communicate mathematical ideas, (b) select, apply, and translate among mathematical representations to solve problems, and (c) use representations to model and interpret physical, social, and mathematical phenomena (NCTM, 2000, p. 67).

The NCTM contends that teachers who are familiar with and trained in the recommendations put forth in *Principles and Standards* present more effective instruction than those who utilize more traditional teaching methods. Consequently, it takes time to achieve this familiarity and training so an increase in the amount of planning time may be key to improving implementation of the NCTM process standards.

Problem Solving

The process standards suggest methods of instruction that teachers may utilize in order to help students acquire appropriate mathematical content. Problem solving is the first process recommended by the NCTM. The NCTM (2000) defines problem solving as "a task for which the solution is not known in advance" (p. 52). The use of problem solving as an instructional method has been emphasized since the early 20th century. Problem solving is a broad educational concept, but its various approaches have several common features. Problem solving includes higher order thinking skills, transference of skills to new situations, the active building of knowledge from experience and prior knowledge (NCTM, 2000). Building new knowledge can be rephrased as making meaning from an educational experience.

Maccini and Gagnon (2000) recommended that teachers incorporate problem solving within real-world contexts in order to activate conceptual knowledge and improve motivation. They reviewed studies that described best practices for teaching mathematics to special needs secondary students. Students in one study were taught either by contextualized problems from a videodisc or by word problems from a teacher-directed approach. All students improved their performance on a contextualized posttest;

however, those taught via videodisc were better able to transfer their problem solving ability to another videodisc problem-solving task.

Serafino and Cicchelli (2003) investigated the effects of utilizing a structured problem solving instructional approach (SPS) with instruction. They compared the SPS approach to a guided generation approach (GG). An SPS approach is teacher directed and paced with a goal of mastery after each step. It also consists of guided and independent practice and moderate use of cooperative learning and discussion. On the other hand, the GG approach is student directed and paced and built on student provided information. The GG approach also consists of guided understanding and transfer of skills and an extensive use of cooperative learning and discussion. The control and experimental groups were composed of 25 fifth grade students who were taught by teachers with similar characteristics. The control group was instructed by use of an SPS approach, and the experimental group was taught with a GG approach. Student prior knowledge scores were equivalent for the groups. Both groups were instructed by video-based anchored instruction provided by the Jasper Woodbury Problem Solving Series. Students were assessed individually and in small groups by answering questions and developing a written plan. The GG students scored significantly higher on the task of group development of a business plan. In addition, low achieving students in the GG model had significantly higher scores than their counterparts in the SPS model. Serafino and Cicchelli recommended that teachers utilize problem-based anchored instruction in all content areas.

Bottge, Heinrichs, Mehta, Rueda, Hung, and Danneker (2004) also investigated instructional approaches to problem solving by comparing two approaches to teaching sixth grade math students. The first approach was enhanced anchored instruction (EAI) which presents problems anchored in authentic contexts that students perceive as meaningful. The second approach was text-based instruction supplemented with applied problems (TBI). The students who were taught by the EAI method significantly outscored those taught by TBI when they were asked to transfer what they learned to a technology education problem.

The NCTM also describes problem solving as applying and adapting a variety of appropriate strategies to solve problems. Maccini and Gagnon (2000) reported that students whose teachers helped them advance through concrete, semiconcrete, and abstract levels had significantly improved problem solving performances as compared to their baseline measures. In addition, they stated that use of calculators was the most prevalent adaptation for students with learning disabilities. Teachers reported that calculators help complete tedious calculations, increase student motivation, decrease math anxiety, and may enhance students' understanding and competence in mathematics.

Brandt and Christensen (2002) focused on utilization of a variety of strategies when they developed a program to improve eighth and ninth grade students' problem solving skills. The students were specifically instructed in the five steps of problem-solving, moral reasoning strategies, and generating alternate solutions from multiple perspectives. After administration of the post-test, the students performed better on identifying the problem and effectively selecting the most appropriate solution. However, they were still deficient in recognizing different points of view. Brandt and Christensen (2002) recommended that teachers instruct students in problem solving strategies to strengthen thinking skills in all disciplines.

Huppert, Lomask, and Lazarowitz (2002) studied technology as a source of problem solving. They examined the effects of computer simulations on high school students' cognitive stages and achievement in microbiology. The simulation reflected the problem solving process by controlling input variables, describing changes over time, and investigating changes in the outcomes. The control group consisted of tenth grade students who were taught in the traditional classroom/laboratory method. The experimental group utilized a computer assisted learning approach (CAL). Pre-test analysis indicated no initial differences between the two groups. Post-test results indicated that students in the experimental group who were in the concrete and transitional operational stages scored significantly higher on a general biology knowledge test than the students at the same developmental levels in the control group. Furthermore, use of CAL enhanced self-paced learning and self-testing which increased student motivation and decreased anxiety. Huppert et al. recommended the integration of CAL lessons into all science courses.

D'Ambrosio et al. (2004) examined the instructional techniques of mathematics teachers at all grade levels in an urban district in an effort to facilitate staff development. They arrived at several conclusions about mathematics instruction that involve problem solving techniques. First of all, they found that more inquiry based instruction took place at the elementary level than at the middle school level and more at the middle school level than at the high school level. In addition, more hands-on instruction took place at the elementary level as compared to both middle school and high school levels, and more computer use occurred at the elementary level. They concluded that calculator usage was greatest at the high school level. Finally, they concluded that despite the district's desire to create a mathematics program based on inquiry and construction of knowledge, the data revealed low use of technology, math projects, and student writing; all emphasized by the NCTM *Principles and Standards*. Not only did their advisement concur with NCTM problem-solving suggestions, but also with reasoning and proof, communication, connections, and representation suggestions.

Like Huppert et al. (2002), Ysseldyke et al., (2004) studied student problem solving skills via technology. They examined students in Title 1 programs who did or did not receive instruction in Accelerated Math (AM). Accelerated Math is a computerized program that allows students to practice problems at their skill level, and it provides instant feedback in addition to assisting the teacher in how to match instruction to the skill level of the student. Results of the study indicated that Title 1 students who received instruction with AM scored significantly higher on a posttest than their counterparts who did not receive instruction with AM.

A third area of problem solving that the NCTM describes is the importance of monitoring and reflecting. Kramarski, Mevarech, and Arami (2002) defined metacognition as "the knowledge and control one has over one's thinking and learning activities" (p. 227). They investigated the effects of metacognitive instruction on solving authentic tasks in mathematics of seventh grade students. Students in the study were divided into two groups based on the instructional techniques of the teachers: cooperative learning incorporated within metacognitive instruction and cooperative learning without metacognitive instruction. The metacognitive instruction consisted of training students to activate metacognitive structures in the areas of comprehension, connection, strategies, and reflection. Authentic tasks were defined as "those which portray common contexts and for which there are no ready-made algorithms" (p. 226). After an entire year of instruction, the students completed a unit in problem solving. Results of a post-test indicated that lower and higher achieving students benefited from the metacognitive instruction and scored significantly higher on authentic tasks in addition to standard tasks. Specifically, students performed better at the tasks of reorganizing and processing information and justifying their reasoning. Effect sizes were higher for higher achievers than for lower achievers.

Self-regulation is also an integral part of the problem solving process strand. Pape and Smith (2002) defined self-regulated students as "active learners who are able to select from a repertoire of strategies and to monitor their progress in using selected strategies toward a goal" (p. 61). Types of problem solvers include students who use a direct translation approach by rotely translating words into mathematical operations and students who actively transform the problem into a meaningful mental model. Pape (1998) studied 80 middle school students and determined that those who solved problems using a meaningful approach as compared to a direct translation approach experienced more success. Smith (1999) developed a 10-week college level developmental math course that integrated learning strategies within the course. After completion of the course, nearly half of the students continued in other mathematics courses and continued to utilize self-regulation skills to successfully complete the other courses.

Chung and Ro (2004) studied the effects of utilizing problem solving instruction on students' creativity and self-efficacy. Third grade students in the experimental group were taught lessons in problem solving for two hours a week for five weeks. Although the pre-tests indicated equality in the two groups with respect to creativity and self-efficacy, the post-test indicated that problem solving skills have a significant effect on the originality subcategory of creativity. The scores for self-efficacy of the experimental group were higher than those of the control group. However, the differences were not significant.

Reasoning and Proof

Principles and Standards (2000) describe reasoning and proof as making and investigating mathematical conjectures and as selecting and using various types of reasoning and proof. The NCTM describes proof as traditionally only practiced with geometric proofs and typically very difficult. They recommend that reasoning mathematically "must be developed through consistent use in many contexts" (NCTM, 2000, p. 56).

Researchers recommend that teachers require students to justify and defend their solutions. Artzt and Armour-Thomas (1999) discussed student justification of answers when they studied the actions of middle and high school mathematics teachers with respect to three dimensions: tasks, learning environment, and discourse. They developed an instrument called the Phase-Dimension Framework (PDF) which examines instructional practices from the lens of the NCTM's (1991) Professional Standards. According to the researcher, part of discourse refers to the learners having the ability to "justify the relationships they observe" and "assume the responsibility for problem-solving" (p. 215). They determined that five of the 14 participants in the study exhibited characteristics of teachers whose instructional practices were most likely to promote student understanding throughout the three dimensions and in practice, interactive, and postactive phases of teaching. Teachers in this group (group X) required students to give full explanations for solutions orally or in writing, encouraged students to respond to each other so they could arrive at conclusions, challenged the students with higher order questions, and utilized appropriate wait time. Another group of participants had instructional practices that were not likely to promote understanding (group Y), and a third group of participants exhibited characteristics of both previous groups (group Z). Group Z resembled group X in their tasks and learning environments; however, they resembled group Y in their discourse. Group Z teachers utilized teacher-directed discussions and did not require detailed explanations of solutions.

Ward, Anhalt, and Vinson (in press) studied the thinking of preservice elementary teachers as they planned for mathematics instruction and determined that preservice teacher use of mathematical discourse; or thoughtful discussion that encourages higher-level thinking, explaining, and justifying; was very limited. In fact, instruction with mathematical procedures or fact giving increased from the initial lesson plans to the final lesson plans, despite the modeling of discourse and model building by the teacher educators. However, after the preservice teachers were able to collaborate with others, use of mathematical discourse increased, thus, potentially increasing higher-level thinking of the students.

D'Ambrosio et al. (2004) studied mathematics instruction in all grades to determine differences in instruction based on grade level. They surveyed teachers and students and determined that the students encountered fewer opportunities to defend their answers and justify their thinking as they progressed from elementary school to high school. In addition, they concluded that elementary students were instructed via hands-on materials and computers in order to test conjectures at higher rates than middle school and high school students were. On the other hand, older students utilized calculators more than those in the middle and elementary grades did. D'Ambrosio et al. recommended that teachers utilize open-ended problems and require that their students show work in order for the teachers to better understand the students' reasoning skills.

One aspect of a study by Morrone et al., (2004) was student higher order thinking skills. They studied preservice elementary education teachers to determine the extent to which the students perceived the class to be focused on mastery goals. The class was an experimental mathematics course and was taught from a social constructivist approach. The teachers' end-of-course evaluations were matched to items from the Patterns of Adaptive Education Learning Scales (PALS) instrument. In addition, the classes were videotaped and analyzed by the Observing Patterns of Adaptive Learning (OPAL) instrument. Part of the OPAL framework is an area referred to as the Task category which includes teacher influences on students' higher order thinking skills. The researchers concluded that 69% of the actions transcribed were categorized as Task items. More specifically, the teacher asked questions, provided scaffolding if responses were not complete enough, and continued to ask more complex questions until the students' responses demonstrated a deep understanding of the concept. Morrone et al. concluded that a social constructivist classroom may enhance students' progression to higher order thinking skills through the means of classroom discourse.

Murphy (2004) analyzed elementary students' use of taught mental calculation strategies. The three children studied employed contrasting counting procedures and mental calculation strategies. The children were taught in a group teaching session about how to perform a specific mental strategy and then later interviewed and asked to solve problems based on the strategy they were taught. The children relied on previously recorded strategy use recorded from a pre-teaching situation. Results indicated that students' mental calculations depend on pre-requisite knowledge and the connections the students can make with other knowledge. Murphy also discussed the evidence that shows higher attaining students are able to utilize a wide range of mental strategies.

Communication

Communication is a very broad area of recommendations by the NCTM. It involves organizing mathematical thinking in order to present to oneself, peers, or teachers; analyzing the mathematical thinking of others; and using the language of mathematics precisely. Aspects of mathematics communication include instruction via small groups such as cooperative learning and discourse. Discourse may be conducted in a verbal or written manner.

Cooperative learning. Cooperative learning requires communication between the teacher and the students and among the students. Teachers who use cooperative learning effectively must teach students how to communicate and work correctly in groups (Protheroe, 2004; Walberg & Paik, 2004).

Several meta-analyses of studies on cooperative learning have been undertaken, and long lists of positive outcomes for students have been compiled (Johnson & Johnson, 1989; Slavin, 1983). The positive outcomes include increases in academic achievement, critical thinking, motivation to achieve, self-esteem and confidence, creativity, ability to generalize, problem solving, and instructional satisfaction. Other positive outcomes include decreases in anxiety, stress, absenteeism, and tardiness (Lenning & Ebbers, 1999). Franca, Kerr, Reitz, and Lambert (1990) determined that peer-tutoring, a form of cooperative learning, improved academic and social skills of middle school students with emotional and behavioral disorders. Neber, Finsterwald, and Urban (2001) determined that cooperative learning "offers strong potentials for further improving the quality of instruction with gifted and high-achieving students" (p. 199). They also concluded that cooperative forms of learning resulted in small to medium positive effects on the achievement of gifted and higher-achieving students in the lower and middle grades.

Good et al., (1989) concluded that using heterogeneous work groups in mathematics classes was an effective instructional technique. They observed a sample of 15 elementary teachers in large urban areas and developed several assertions. First of all, more students were able to communicate ideas with each other as compared to students in homogeneous achievement groups. In addition, the lessons were posed in a problem solving manner so the students' higher level thinking skills were initiated, and their motivation to find a solution was improved.

Maccini and Gagnon (2000) considered cooperative learning groups in mathematics courses with special needs students as an effective method of implementing the NCTM standards. The researchers surveyed secondary general and special educators in Maryland with an instrument that contained open-ended questions about the goals of the NCTM standards and their knowledge of learning disabled and emotionally disturbed students. The teachers listed three instructional techniques they felt would improve implementation of the standards. One of the techniques was use of cooperative learning groups which may take the form of a group of three or four students or may take the form of a peer tutoring partnership. The teachers responded that they felt students working together benefited both academically and socially.

Yamaguchi (2003) studied the effects of learning groups on middle grade students' emergent leadership, dominance, and group effectiveness. The students were divided into ten three-person groups, and some performed a mathematics task under mastery conditions while others performed the same task under performance conditions. Mastery conditions for this study referred to an emphasis on learning and improving to the best of the students' abilities and without the presence of a test. Performance conditions referred to completion of the task correctly in order to test the students' abilities and determine who had the best scores on the task. The groups who performed under the mastery conditions exhibited more positive behaviors, more discussions about math strategies, and stayed on focus more. The groups that performed under the performance conditions exhibited more negative behaviors, off-task behavior, and group isolation. The researcher's recommendation was for teachers to create a classroom climate that emphasized learning rather than just scoring the highest grades. Cooperative learning was also recommended as an effective means to create the learning environment.

Morrone et al. (2004) utilized the Patterns of Adaptive Education Learning Scales (PALS) and the Observing Patterns of Adaptive Learning (OPAL) instruments to determine if instructional discourse influenced the perception of classroom mastery goals. The preservice teachers in an experimental mathematics course worked through problems as groups and then convened as an entire class for each group to share its solution with other groups. The researchers suggested that a social constructivist classroom gives the students "ownership in determining whether their solutions are correct" (p. 34). Morrone et al. suggested that a social constructivist classroom, which typically utilizes cooperative learning groups, may enhance meaningful discourse among students.

D'Ambrosio et al. (2004) surveyed 950 students at all grade levels in a large urban district about the instructional techniques they experienced in math class. The students' reports indicated that frequency of group work decreased as students progressed through higher grades; however, the teachers reported a much higher incidence of group work. The researchers saw student-student interactions as a necessary part of a mathematics program based on inquiry and constructivism, so they structured professional development activities for teachers that emphasized group work. The teachers played the part of learners and worked in small groups to solve problems and discuss solutions as a community of learners.

Discourse. Instructional techniques that involve communication also include discourse which requires the students to engage in thoughtful discussions and writing. St. Clair (1998) reported evidence of the benefits of using language (reading, writing, and discourse) as part of mathematics instruction since they are forms of problem solving. In addition, integrating language skills with mathematics skills is a practical approach to instructing students in skills they need to "cope in a complex society" (p. 4). Finally, St. Clair cited research that substantiates use of language skills to benefit mathematics teaching and learning. St. Clair also suggested topics of dialogue in math classes such as the process of mathematical activities, feelings about mathematics, and debates about mathematics. She recommended that the dialogue consist of questions, explanations, conjectures, and debates that are interactive among the teacher and students.

Discourse can be teacher initiated but should eventually become more student-dominated in which the students make predictions, clarify, or justify their responses (Brophy, 1999). Fennema, Sowder, and Carpenter (1999) contended that if students are expected to explain and justify their responses on a regular basis, then the development of mathematical thinking and self-regulated learning is facilitated. Pape and Smith (2002) believed that students are exposed to strategies used by other peers as well as the teacher when classroom dialogue takes place. Furthermore, they stated that dialogue facilitates self-reflection, and therefore self-regulation, skills that are also important.

Lambert (1990), Yackel, Cobb, and Wood (1991), and Richards (1991) determined that a mathematics teacher could facilitate learning by encouraging dialogue with students and among students. Lambert (1990) instructed fifth grade students to use the correct mathematical language to question other's hypotheses and discuss until consensus was reached. In addition, she guided her students to discover a law of exponents without an explicit explanation from her. She required them to make tables of the squares from one to one hundred, look for patterns, make conjectures, and debate until consensus is reached about the pattern. Yackel et al. (1991) utilized small group problems followed by whole class dialogue in order to help facilitate the problem solving ability of second graders. Richards (1991) explored the abilities of tenth graders to engage in a conversation about the process used to solve a mathematical problem. At the beginning of the researcher's visit to the class, the students were not able to engage in a mathematical conversation. Throughout the study, Richards modeled the correct vocabulary in dialogues with the students. By the end of the study, the students were able to explain the solutions to problems and collaborate with peers in the problem solving process.

Artzt and Armour-Thomas (1999) determined that discourse was an essential component of the instructional practices of secondary math teachers with respect to their cognitions. Although, seven of the 14 teachers studied were experienced (7 to 25 years), only four of them and one novice teacher exhibited practices that were likely to promote student learning with understanding (group X). The researchers determined that the five teachers who successfully promoted understanding utilized discourse in three areas: teacher-student interactions, student-student interactions, and questioning. The teachers stated the lesson objectives to the students, encouraged all of the students to think and reason, and allowed students to respond to each other's ideas. In addition, the teachers used student responses to monitor understanding and then supplement the lesson with additional instruction if necessary. The teachers in group Y utilized practices that did not promote student understanding, and the teachers in group Z exhibited characteristics of both groups X and Y. Group Z teachers promoted understanding with their tasks and learning environments, but not their discourse. Artzt and Armour-Thomas urged teachers to initiate discourse in their classrooms even if there is limited time to cover the content.

Ward et al. (in press) studied the lesson plans of preservice elementary education teachers to investigate their thinking as they planned for mathematics instruction. One aspect of the investigation involved language use of the preservice teachers. The desirable language approach to teaching the lesson was to engage the students in mathematical discourse (L_2), defined as thoughtful discussion that encourages higher-order thinking skills and requires justification and explanations from the students. The use of procedural language (L_1) increased from the initial lesson plans to the final ones, and the use of mathematical discourse remained infrequent throughout the course. On the other hand, as the preservice teachers collaborated in groups, use of discourse increased.

Sherin, Mendez, and Louis (2004) concluded that the middle school classroom they studied underwent a transformation to a discourse community. In a discourse community, the teacher must design classroom discussion by obtaining student ideas and pursuing one or some of them. The middle school mathematics teacher at the center of the study collaborated with two university researchers in an effort to transform his classroom into a community of learners (Sherin et al., 2004). The tools that may enhance discourse include calculators and computers and methods of representation (NCTM, 2000). The middle school teacher focused on fostering discourse by requiring students to explain and discuss their ideas. Furthermore, the teacher created a safe community so he could question and probe the students for detailed explanations without intimidating the students so that they would not respond (Sherin et al., 2004).

Communication skills also include writing skills. Stonewater (2002) enumerated many benefits of student writing. First of all, writing aids in improving students' general learning and problem solving skills as well as metacognitive skills. Writing is also a means of explaining and justifying student responses which is an important means to higher level thinking (Busatto, 2004; Fennema et al., 1999). Pape and Smith (2002) asserted that writing is a necessary part of achieving self-regulation abilities. As an illustration, they described an instructional process in which the students were required to correct and analyze their own mistakes in mathematics problems.

Nahrgang and Peterson (1986) described the merits of journal writing in math classes. They asserted that journal writing is flexible; the assignment may be one that is very specific or one that allows the student freedom of expression. In their study, they had college students write in journals twice a week about mathematical concepts. They did not grade the journals, instead giving bonus points toward tests and recording comments. They determined that journal writing allowed the students to make connections between new material and prior knowledge, draw conclusions, make connections between mathematics and the real world, and internalize mathematical ideas, thereby learning the content better. In addition, Nahrgang and Peterson determined that journal writing benefits the teachers by helping them to identify students' misconceptions and helping them to better meet student needs. Borasi and Rose (1989) added that journals allow students to reflect on their feelings about mathematics and create a classroom in which communication between teacher and students is more open.

Bell and Bell (1985) examined the effects of schematic writing on students' problem solving ability. Schematic writing refers to explanations of solutions or proofs. The sample consisted of ninth grade students in a general mathematics class. The instructor divided the class into three parts: the process of problem solving, problem analysis, and student creation of problems. The experimental group completed writing assignments in addition to the math problems. The students were required to explain in writing how to solve problems, what solution method they preferred, and why. In addition, the students were asked to analyze problems and determine what information was missing and evaluate if the problem could be a real life situation. Finally, the students were asked to generate their own word problems and provide a written explanation of each. Furthermore, the students in the experimental group had to exchange papers and critique each other's work. Bell and Bell determined that both the control and experimental groups' demonstrated improvement in problem solving skills; however, the experimental group significantly outscored the control group. The researchers recommended that teachers use schematic writing on a regular basis since it did not require any extra materials or preparation.

Winograd (1990) studied the effect of writing story problems on students' cognitive behavior and beliefs about mathematics. The fifth grade students created story problems three to four times per week, shared them with their peers in small groups, and worked each other's problems. The researcher determined that the class became a community with students collaborating on solutions and striving to create challenging and interesting problems. On the other hand, negative effects included students who may have said they understood when they did not or aggressive students who did not allow for understanding by all students in the group. Finally, Winograd concluded that the writing had positive effects on the students' beliefs about math class.

Jacobs (2004) concurred with Stonewater (2002) in that writing helped with the growth of metacognition. She studied metacognition in kindergarten children during the writing process. She interviewed 16 kindergarteners twice a month as they finished writing assignments and completed checklists of their progress. She determined that kindergarten children were capable of metacognition. In addition, as the year progressed, there was an increase in the number of students who could answer questions about how the idea came into their minds and an increase in the quality of their answers, an indication that metacognitive growth had occurred. Jacobs contended that writing aids students in constructing knowledge in their own language and makes their thinking clearer and that writing helps students to make connections, organize, synthesize, and analyze ideas.

St. Clair (1998) conducted an extensive survey into Algebra teachers' use of writing and dialogue as instructional strategies. She surveyed 449 algebra teachers in 63 schools about their beliefs and practices concerning utilization of writing and discourse in their classes. The study concluded with several findings. First of all, most of the teachers indicated traditional beliefs about language areas such as taking notes, reading the text, completing worksheets, and question/short answers. In addition, the teachers reported low usage of traditional and nontraditional language activities. Nontraditional language activities include reading stories, essays, or biographies; creative and expressive writing; and dialogue among teachers and students that may explain processes and feelings. More specifically, larger percentages of teachers reported usage of nontraditional writing than usage of nontraditional dialogue techniques. Furthermore, most of the teachers reported traditional mathematics/teaching beliefs and traditional language area beliefs. St. Clair concluded by theorizing that for ideal implementation of language areas into mathematics instruction, teachers' beliefs about mathematics/mathematics teaching must first be transformed.

Connections

The NCTM asserts that when "students connect mathematical ideas, their understanding is deeper and more lasting" (p. 64), and suggests that the curriculum be coherent and not fragmented. Therefore, one of its process standards promotes the idea of connections (NCTM, 2000). Connections can be made to other math topics, other subject areas, or real life such as home or work situations (Maccini & Gagnon, 2000). Many researchers recommend that instruction emphasize the connection between mathematics and the real-world (Groves, Mousley, & Forgasz, 2004; Weiss & Pasley, 2004).

Carpenter and Lehrer (1999) further proposed five mental activities from which understanding emerges; two of the activities involve connections. They recommended that teachers help students to construct relationships by relating the material to prior knowledge already possessed by the students, especially knowledge that pertains to concepts outside of school. In addition, Carpenter and Lehrer recommended that students be taught how to extend and apply mathematical knowledge. They described this ability as the "creation of rich, integrated knowledge structures" (p. 21) in which new knowledge can easily be incorporated. Moreover, they asserted that structured meaningful knowledge is less likely to be forgotten. Finally, Carpenter and Lehrer disagreed with many educators who believe that basic skills must be learned before the complex function of application is introduced. They believed that students intuitively solve meaningful problems before basic skills are learned.

One aspect of teaching that Artzt and Armour-Thomas (1999) investigated was the task of motivating students to learn. The researchers listed the skill as "provides tasks that capture students' curiosity and inspires them to speculate and to pursue their conjectures" (p. 217). Some educators refer to this form of making connections as an advanced organizer (Ausubel, 1960; Mayer, 2003) or a sponge (Busatto, 2004). The teachers in group X exhibited the instructional technique, whereas, the teachers in the other two groups did not. Artzt and Armour-Thomas determined that group X teachers were more likely to teach lessons that promote understanding.

Making connections is especially useful for students with special needs. Maccini and Gagnon (2000) recommended that teachers help special needs students to make connections in mathematics to facilitate learning and enhance student value of mathematics. The researchers surveyed a representative sample of secondary general and special educators to determine their ideas about the goals of the NCTM with respect to LD and ED students. The teachers' second most prevalent response to the question of what instructional approaches best implement the NCTM standards was real-life application. The teachers believed that real-world applications help students generalize math skills and responded that they often utilized contextualized learning. In addition, the teachers responded that they often used scaffolding to help the students make connections. Finally, Maccini and Gagnon asserted that real-life applications can help students stay on task and cited a study in which ED students learned mathematics by managing a classroom-based business. The students' on-task behavior improved after the intervention of the business unit went into effect.

Connections were also evident in findings by Morrone et al. (2004). They studied a class of preservice elementary teachers in an experimental mathematics class. The goal of the class was to "help students understand mathematics in a connected and meaningful way rather than a set of prescribed rules" (p. 26). The researchers observed the TARGET behaviors, as proposed by Epstein (1999), of the instructor. The task element of the TARGET framework consisted of scaffolding and pressing for understanding. Scaffolding is defined as the teacher providing support for learning by modeling, outlining, questioning, or suggesting additional resources. Press for understanding is defined as the teacher pressing the student to elaborate, think more deeply, make connections to prior knowledge, or think about relationships between ideas. The results of the study indicated that most of the teacher behaviors (69%) were categorized as task elements. Morrone et al. asserted that their study provided evidence that classroom discourse and an environment that promotes mastery goals aids the students in achieving higher-order mathematical thinking.

Stigler and Hiebert (2004) examined the data from the TIMSS 1995 video study and concluded that countries whose teachers spent time introducing problems as concepts connected to other areas rather than facts presented with algorithms scored higher on the TIMSS assessment. Even though many teachers in the video study introduced problems as concepts, some transformed the problem into a procedural one. For example, 17% of the problems presented by U.S. teachers in the TIMSS video were concept problems; however, none of the concept problems were presented as a making connections problem. Stigler's and Hiebert's study provided evidence for the making connections method of implementing mathematics problems.

House (2004) examined data from the TIMSS 1999 study, specifically the Japanese students, and gleaned results that concurred with Stigler's and Hiebert's (2004) results. Based on student responses, he determined that those who utilized aspects of everyday life when solving mathematics problems earned higher achievement scores on the assessment.

Representation

The NCTM asserts that the manner in which mathematical ideas are represented is fundamental to understanding. Representations are "a set of tools that significantly expand their [students'] capacity to think mathematically" (p. 67). Traditional forms of representation include diagrams, graphs, and symbolic displays; however, new forms associated with electronic technology must now be considered by teachers (*Principles & Standards*, 2000). Lesh, Post, and Behr (1987) described five levels of representations of mathematical ideas: concrete, language, symbolism, semi-concrete, and contextual. They contended that by strengthening students' abilities to move among representations, conceptual understanding is improved. Ward et al. (in press) examined the lesson plans of preservice teachers who were enrolled in an elementary mathematics methods course. The researchers coded initial individual lesson plans, group lesson plans, and final lesson plans with respect to the categories developed by Lesh et al. In addition, the language representation was divided into procedural language (L_1) and mathematical discourse (L_2). Several findings arose from the study. First of all, language, especially L_1, and symbolism were the most frequently used representations. Contextual representation was the least frequently used, and in fact, its frequency decreased from the initial plans to the final ones. Use of concrete representation (manipulatives) increased slightly. Ward et al. posited that the effectiveness of the lesson plan depends on who uses the representation (students or teacher) and how the representation is used. They also recommended the inclusion of representation in mathematics methods courses.

Hirsch and Coxford (1997) contended that modeling, a type of representation, allows students to make sense of situations when they investigated teacher reaction to the implementation of the Core-Plus Mathematics Project. For example, students use graphing calculators to examine and manipulate scatterplots and lines of best fit. The exercise not only connects algebra and statistics, but also reflects real-life data. In addition, teachers reported that some students utilized the computer or geoboards to represent patterns while others were more abstract and utilized symbolic representation for the same assignment. Diversity needs were met since the students were able to utilize different means to represent the patterns.

Glick et al. (1992) studied identified sources from which secondary science and mathematics student teachers develop instructional representations. Glick et al. expanded the definition of representation from that of the NCTM to include all activities, examples, demonstrations, and analogies that teachers use to help students learn. Most of the responses indicated instructional ideas came from the adopted curricular material, were created by the teachers themselves, were modifications of already existing materials, or were suggestions or materials offered by the cooperating teacher. Very few ($\leq$ 3%) lesson ideas came from teacher preparation courses, personal experiences, or other teachers. The researchers recommended that teacher preparation programs emphasize how to modify existing material or create original materials. Since the cooperating teacher was a large influence on lesson development, Glick et al. also recommended that selection of cooperating teachers should be carefully done.

Artzt and Armour-Thomas (1999) included modes of representation as part of the task dimension they were seeking in their sample of teachers. One indicator for modes of representation consisted of the teachers providing representations such as symbols, diagrams, manipulatives, and computer/calculator displays to facilitate content clarity. Another indicator consisted of the teacher providing multiple representations that aid students in connecting prior knowledge to new knowledge. The researchers examined the practices of 14 math teachers and determined that only five of them met the criteria of practices that promote student understanding in the three dimensions of task, learning environment, and discourse. Artzt and Armour-Thomas recommended that their instrument, the Phase-Dimension Framework, serve as a model for preservice teachers to improve their instructional practices.

Maccini and Gagnon (2000) surveyed general and special educators at the secondary level. The teachers reported that one of the most prevalent ways they implemented the standards with LD and ED students was by use of manipulatives to enhance conceptual understanding instead of rote learning. Manipulatives that the teachers favored included two-color counters for positive and negative numbers, a balance mat to aid with equations, and Algebra Lab Gear. The researchers described a study where LD students were asked to represent a relational statement by using manipulatives. After completing three trials with no mistakes, the student was asked to represent the same situation with a picture. After three trials with no mistakes, the students were asked to represent the situation as symbols in an algebraic equation. Results indicated that the students' problem solving performances improved significantly from their baseline measures in representation. Maccini and Gagnon enumerated guidelines for manipulative use with students who have disabilities: select manipulatives that are connected to the concept and students' developmental levels, incorporate a variety of manipulatives, and aid the students in transition from concrete to symbolic representation.

Trends in Effective Teaching Practices

As educational trends are examined, a pattern of effective instructional techniques emerges around which this study is developed. In 2000, Marzano, Gaddy, and Dean enumerated a list of effective instructional approaches that apply to any subject matter and improve achievement. The approaches include generating and testing hypotheses, non-linguistic representations, cooperative learning, and activating prior knowledge. Marzano's approaches are plentiful in the literature that relates teaching practices to NCTM recommendations. Weiss and Pasley (2004) studied U.S. mathematics and science lessons from all grade levels. They determined that only 15% were high quality, 27% were medium quality, and 59% were low quality. Quality was defined by indicators such as the quality of the content, the quality of the implementation, and the extent to which the classroom facilitated learning. High quality classrooms were likely to engage students in learning and promote understanding. Features of a high quality classroom that are emphasized in this proposed study include student engagement with content, effective questioning, assistance in making sense of the content, the instructional decisions of teachers, and the preparation and support of teachers.

Smith and Geller (2004) described essential principles of effective mathematics instruction. They enumerated specific tasks in planning the lesson and then teaching the lesson. Among the planning steps are the recommendations for allowing sufficient time to determine prior knowledge before the introduction of new skills; connecting word problems to the students' lives; and preparing concrete, pictorial, and abstract models to demonstrate the problem. Among the teaching steps are recommendations for presenting real-life examples and nonexamples; guiding the students with concrete, pictorial, and abstract models; and requiring the students to verbalize solution steps to problems.

Maccini and Gagnon (2000) described best practices for teaching mathematics to secondary students with special needs based on a survey of general and special educators. The researchers offered several recommendations. Effective instructional techniques that the sample listed included teacher modeling, monitoring of student performance, and using a variety of examples and nonexamples. In addition, use of manipulatives was recommended, especially those that started as concrete and progressed to abstractness. Furthermore, calculator activities that were teacher-directed and discovery-based were suggested. Finally, use of problems within a real-life context and cooperative learning groups were recommended.

The NCTM principles and standards align with the recommendations proffered by research. The principles state that mathematics can be learned by all with a curriculum that is coherent, well-presented, and well-supported. They also state that learning is understanding, not just memorization, and that technology may enhance learning. Finally, the principles state that assessment should furnish information to the students and teachers. The content standards assert that mathematics can be divided into the main topics of numbers and operations, algebra, geometry, measurement, and data analysis/probability. The content standards can be taught at all grade levels. The process standards assert that the content standards may best be acquired through problem solving, reasoning and justification, communication, connections, and representation. Problem solving techniques that are recommended in the literature include looking for patterns with or without the aid of technology and using inquiry methods. Self-regulatory and reflective skills are also important for teachers to emphasize. Reasoning and proof exercises that are described in the literature include making and testing conjectures, questioning that involves higher-order thinking skills, and requiring explanations for solutions. Communication techniques that are recommended in the literature include using small group work to problem solve, engaging in classroom discourse in either oral or written form that involves all students, and using journals to help students verbalize mathematics. Techniques that help students form connections are embedding problem solving activities in real-life situations that relate to prior knowledge, another math topic, another subject such as science, home life, or work applications. Finally, representation techniques that are found in the literature include use of manipulatives or mathematical models to facilitate student thinking from concrete to abstract levels and using multiple modes of representation to meet the needs of a diverse body of students.

In conclusion, research shows that adequate planning time and collaborative planning enhance effective teaching practices (An, 2001; Burns & Reis, 1991; Decker, 2000; Glatthorn, 1993; Misulis, 1997; Ornstein, 1997; Panasuk et al., 2002; Welch, 2000; Wolf, 2003; Yinger, 1980). Specifically, the teachers in the Goals 2000 Teacher Forum identified time as the most critical aspect for successful school reform (Livingston, 1994).

The NCTM has urged that teachers reform their manner of mathematics instruction and has outlined its recommendations for effective teaching in Principles & Standards (2000). Moreover, the literature supports the NCTM recommendations (Artzt & Armour-Thomas, 1999; Bottge et al., 2004; Glick et al., 1992; Good et al., 1989; Huppert et al., 2002; Maccini & Gagnon, 2000; Morrone et al, 2004; Pape & Smith, 2002; Serafino & Cicchelli, 2003; Sherin et al., 2004; Smith & Geller, 2004; St. Clair, 1998; Stigler & Hiebert, 2004; Ward et al., in press; Ysseldyke et al., 2004). The process standards proposed in Principles & Standards align closely with the effective teaching strategies described in planning literature. The National Commission on Teaching and America's Future asserted that "what teachers know and can do is the most important influence on what students learn" (1996, p. 6). Therefore, it is the intent of this study to investigate whether allowing more time for individual and collaborative planning may influence teacher implementation of NCTM recommended teaching practices.

CHAPTER THREE: DESIGN OF THE STUDY

"Research is the systematic application of a family of methods that are employed to provide trustworthy information about problems" (Gay & Airasian, 2000, p. 3). This chapter explains the general procedures used to investigate the planning habits of high school mathematics teachers in West Virginia and their usage of National Council of Teachers of Mathematics (NCTM) recommended instructional strategies. More specifically, the study examines the planning times and instructional practices of high school Algebra 1 and Applied Math teachers. This chapter includes a description of the research design, population, data collection procedures, instrumentation, and planned statistical analyses of the data.

Research Design

The study was classified as having a cross-sectional descriptive design. The study attempted to take teachers who differ on the independent variable of planning time and compared them on the dependent variable of frequency of use of instructional strategies. The information was examined using an ex post facto design since both the independent and dependent variables had already occurred. In addition, demographic information was collected in order to develop a profile of teachers who more frequently used NCTM recommended strategies. Gay and Airasian (2000) asserted that descriptive research is useful for investigating educational problems and issues.

Population

The population for this study consisted of secondary (grades 9-12) Algebra 1, Applied Math 1, and Applied Math 2 teachers in the public schools in West Virginia.

The teachers were certified in math and were currently teaching math. West Virginia teachers comprised the population because information regarding them was readily available from the state department of education. The focus was on Algebra 1, Applied Math 1, and Applied Math 2 teachers because nearly all secondary school students take some form of Algebra 1. Applied Math 1 and Applied Math 2 teachers were included in the population because students receive credit for Algebra 1 after having completed both courses. It was the intent of the researcher to study practices at the high school level only; therefore, Algebra 1 teachers at the middle school level were eliminated from the study. The research design utilized an ANOVA design; therefore, the entire population was studied in order to have enough subjects per cell of the ANOVA. The population of mathematics teachers in grades 9-12 who teach Algebra 1 or Applied Math was provided by the West Virginia Department of Education (WVDE) and numbered 800. The researcher examined the population to remove teachers who were not certified in math, such as special education teachers, therefore reducing the population to 478.

Instrumentation

The *Mathematics Instructional Practices Survey* was used by the researcher to collect data for this study (Appendix A). The independent variables were the length of individual planning time and the length of collaborative planning time. Individual planning was defined as time utilized by the teacher to prepare lessons and materials prior to instructional delivery or to reflect on the effectiveness of previous instruction. Collaborative planning was defined as time utilized by two or more teachers who together plan lessons or reflect on past lessons for purposes of instructional improvement.

The teachers did not necessarily co-teach. The dependent variable was the reported frequency of use of various instructional practices.

A comprehensive review of the literature suggested that no instrument was available to measure instructional techniques with respect to planning time. However, the *Mathematics Instructional Practices Survey* was adapted from one created by Butty (2000) that examined the instructional practices of high school mathematics teachers. Input was also gathered from the dissertation committee chair and a panel of experts.

Construction of the Survey

Part 1 of the survey collected information about planning procedures utilized by the participants. Planning was defined on the instrument so that the respondents would not include time for grading, parent conferences, making copies, etc. Other information garnered by the survey was minutes spent in planning per week at school and at home and the value placed on collaborative planning.

The survey asked the teachers to list the average amount of time spent planning, individually and collaboratively, rather than to check off a category already prepared by the researcher. Checking off categories may encourage the teachers to choose a time that was longer than the time they normally planned. The average planning time in minutes was based on a week of instruction. Some schools in the state were on an alternating block schedule which meant that they taught classes every other day so that it took two weeks of time to equal a week for classes that are taught daily. The teachers listed the amount of time so that they did not have any preconceived notion of low, average, and high amounts of weekly planning time and inflate the amount of time spent planning.

The amount of time spent planning at home is important because many teachers planned lessons outside of school hours.

The survey emphasized the definition of planning time as time spent planning for instruction or reflecting on prior instruction so that the teachers would not include time spent grading papers or completing administrative tasks. The survey also emphasized the two tasks of individual planning and collaborative planning. After the data were collected, the researcher divided the reported planning times into quartiles. The researcher then drew comparisons among the use of instructional strategies of the respondents in each of the four quartiles.

Part 2 of the survey consisted of 41 instructional techniques that are recognized in the literature as either examples of the NCTM recommended process standards or traditional techniques (See Appendix B). The *Mathematics Instructional Practices Survey* was developed to gather data and designed in the form of a Likert scale. Scales have the advantage of increased reliability over separate questionnaire items (Smith & Glass, 1987). The instrument measured the frequency given to use of instructional strategies that define the process standards as well as additional traditional instructional practices. Within the literature review, the researcher defined each process standard by skills that the literature supported as being part of each standard. The teachers in the study reported how much the various instructional strategies were used by responding as never, rarely (1 or 2 times per semester), occasionally (1 or 2 times per month/ 1 or 2 times per two months), frequently (1 or 2 times per week/ 1 or 2 times per 2 weeks), or daily (each day of class). The strategies were presented in a random order so that the respondents would be unaware that they were the NCTM process standards. In addition, some traditional practices were included in the survey so respondents would be able to mark something on the survey whether they followed NCTM recommendations or not. In addition, there was an area on the survey instrument in which the respondents could add comments of their own. The focus was on frequency of use rather than appropriateness of use because the purpose of the study was to determine if a difference existed based on duration of planning time.

Part 3 of the survey collected demographic information about the participants. Demographic information included sex, age, teaching experience, math teaching experience, highest degree attained, recent attendance at a professional conference, and membership in professional organizations. The demographic information helped the researcher develop profiles of teachers who planned longer, collaboratively planned, or emphasized the NCTM process standards. Furthermore, any differences between novice and experienced teachers were determined by the study. The demographic portion was strategically placed at the end of the survey. According to Babbie (1973), the participants may focus more on the main points of the survey when they are not immediately faced with routine demographic questions.

Survey Validity

The *Mathematics Instructional Practices Survey* was initially reviewed for content, style, and validity by a panel of six curriculum experts, including three county level supervisors and three state level supervisors who work at the West Virginia Department of Education (See Appendix C). Since the instrument was developed by the researcher, validity was determined by a panel of experts in the subject addressed in the survey (Johnson & Christenson, 2000). The experts were provided with a list of questions to guide their review of the readability of the survey questionnaire (Smith & Glass, 1987). Appendix D provides a list of the questions utilized by the panel. Content validity describes the degree to which an instrument actually measures the entirety of the concept it is designed to measure (Babbie, 1973). The suggestions for improvement were reviewed by the dissertation author and committee before finalizing the survey instrument. After suggested revisions from the experts were made, the *Mathematics Instructional Practices Survey* was piloted with a group of 11 high school mathematics teachers to determine test reliability.

The survey was constructed to ensure readability and minimum response time for the participants. First, definitions of planning time were clearly presented at the beginning of Part 1. The definitions were based on what the literature says about ideal instructional planning time. Second, the instructional practices in Part 2 of the survey were all from literature about best practices in mathematics teaching. The instructional practices reflected the wording that the NCTM uses in its standards documents. Finally, the survey was comprised of restricted choices to keep the participants focused on the practices reflected in the literature. However, a blank area was provided at the end of Part 2 for the participant to make comments.

Survey Reliability

The use of the NCTM standards was a representative base for this study in that the NCTM is the world's largest organization with the mission of improving mathematics education. It has over 100,000 members worldwide (NCTM, About NCTM. n.d.). The NCTM has an affiliate in West Virginia, the West Virginia Council of Teachers of Mathematics (WVCTM). Furthermore, West Virginia's State Board of Education Policy

2520.2 which defines the state's mathematical standards for public schools aligns the state's Content Standards and Objectives (CSOs) directly with the NCTM content standards published in 2000 (WVBOE, 2003). The policy was developed by committees of educators from across the state. As a result of the prevalence of the NCTM within the state, educators who completed the survey were familiar with the recommendations put forth in the *Principles and Standards*. Finally, an abundance of literature describing best practices in mathematics instruction referred to the NCTM as a source.

To ensure that the survey instrument is reliable, a Cronbach's alpha coefficient was calculated from a field test of the survey. Cronbach's alpha coefficient estimates "internal consistency reliability by determining how all items on the test relate to all other test items and to the total test" (Gay & Airasian, 2000, p. 174). It is appropriate if numbers are used to represent response choices such as with Likert scales. The Cronbach alpha coefficient for the study was .85 thus indicating strong reliability.

Data Collection

Research Survey Packet

This research project used the *Mathematics Instructional Practices Survey* to collect data. Individual teacher packets were mailed to each high school in the state. The packet consisted of a cover letter, survey, instructions, and a return envelope. The cover letter (See Appendix E) introduced the researcher, described the project, and informed the participant that completion of the instrument was voluntary and confidential. The packet also contained the project survey instrument with directions for completion and a postage-paid, self-addressed envelope in which to return the completed survey. The survey contained no identifying marks; however, as suggested by Marshall's Institutional

Review Board (IRB) director, the envelopes were marked so that they may be placed in a separate pile from the surveys in order to aid the researcher in identifying those who needed to receive subsequent mailings. The participants were asked to return the surveys within three weeks. A return rate of at least 50% plus 1 was desired as a minimal number of sufficient responses for the population size of the study (Babbie, 1973).

Survey Returns

The first distribution of the questionnaire was mailed to the entire population of certified Math teachers who teach Algebra 1 or Applied Math. The population was determined by the WVDE for the 2006-2007 school year. Most of the teachers worked at a high school, but some of the ninth grade teachers worked at a junior high school. A follow-up letter (See Appendix F) and survey packet was sent after the initial deadline of three weeks elapsed to achieve a maximum number of responses. Subsequent postcard reminders and follow-up phone calls were made as needed. According to Babbie (1973), Smith and Glass (1987), and Gay and Airasian (2000), providing follow-up letters is an effective method for increasing the rate of returns in survey research.

General Analysis of the Research Questions

The data from Parts 1 and 2 of the survey were recorded, coded, and analyzed using the SPSS computer program. The responses in Part 1 assessed the planning practices of the participants which was the independent variable of the study. The responses in Part 2 assessed the frequency of specific instructional strategies used by the participants which was the dependent variable of the study.

The responses from Part 3 of the survey were recorded and coded in the SPSS program. These responses were at the nominal level of measurement because they were descriptions of characteristics of math teachers in West Virginia.

The data were aggregated by the quartiles of planning times (4 groups), by the 5 process standards (5 groups), as well as individual versus collaborative planning (2 groups). So there were 20 groups of data for individual planning and 20 groups for collaborative planning. The data were analyzed with descriptive statistics and inferential statistics. Gay and Airasian (2000) contended that the most commonly used inferential tests to compare groups are t-tests. However, since there were many groups to be compared, analysis of variance (ANOVA) tests were performed to determine what differences existed, if any, in the cumulative frequencies for each group. By using the mean of cumulative frequencies, the data were transformed into continuous data thus, making the ANOVA test an appropriate test to utilize. The Fisher's Least Significant Difference (LSD) multiple comparisons test was performed to determine where differences existed.

The research questions of this dissertation were addressed by using the following statistics:

Research Question 1: What differences exist in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of individual planning time?

The responses to this research question were analyzed using the ANOVA test for each of the 20 groups regarding individual planning time. The ANOVA test was used to show differences, if any existed, in the mean of the frequencies of the groups. If the F ratio showed significance then the null hypothesis would be rejected: There is no difference in the frequency of use of various strands of instructional strategies as related to the individual planning times of high school Algebra 1 and Applied Math teachers.

Research Question 2: What differences in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of collaborative planning time?

The responses to this research question were analyzed using the ANOVA test for each of the 20 groups regarding collaborative planning time. The ANOVA test was used to show differences, if any existed, in the mean of the frequencies of the groups. If the F ratio showed significance then the null hypothesis would be rejected: There is no difference in the frequency of use of various strands of instructional strategies as related to the collaborative planning times of high school Algebra 1 and Applied Math teachers.

CHAPTER FOUR: PRESENTATION OF FINDINGS

This study was designed to examine whether differences existed in the perceived mean frequency of use of several groups of instructional practices by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of individual and collaborative planning time. The instructional practices (See Appendix B) that are examined consist of those defined by the process standards of the National Council of Teachers of Mathematics (NCTM). In this chapter, research questions along with the corresponding null hypotheses are presented followed by a statistical analysis of each. Population demographics and ancillary findings are then presented.

Participants

The participants consisted of the entire population of math teachers in grades 9-12 who teach Algebra 1 and Applied Math. The original population of 800 was reduced to 478 after the researcher added the criterion that the teachers be certified in mathematics or hold an Algebra 1 certification. An initial mailing, second mailing, and subsequent reminder phone calls and post cards resulted in 243 responses, representing 50.83% of the surveyed population. While the mailings resulted in 243 returned surveys, the number of responses for each statement on the survey varied due to the nature of a self-report survey, so there were some missing data values. There were 245 cells of missing data out of 11,664 total responses (48 objective items x 243 surveys) which amounts to 2.1% missing data.

Major Findings

This section presents major findings organized to correspond to each research question. All research questions were answered by utilizing the instrument the *Mathematics Instructional Practices Survey*. The survey consisted of two parts, one part asking the respondents to describe their planning times, and a second part in which respondents reported the frequency that they used various instructional strategies.

The data were analyzed using SPSS 14.0. The independent variables in the study were reported individual and collaborative planning times. The dependent variables in the study were the mean frequency scores of the participants for the instructional strategies. The individual and collaborative planning times of the teachers were divided into quartiles, and the mean of the frequencies of use of the NCTM recommended strategies was calculated for each respondent, and referred to as mean NCTM score, to answer the research questions. Furthermore, the instructional strategies were collapsed into five variables corresponding to the process standards detailed by the NCTM. Although some of the strategies overlap into more than one standard, the researcher placed the strategies in groups based on the description of the standards in *Principles and Standards* (2000). Survey statement Part 2 number 38: *make choices as to project* was eliminated by the researcher because it was very similar to number 31: *complete a project that takes several days*. In addition, descriptive statistics were calculated for each of the independent and dependent variables. Table 1 provides a display of how the instructional strategies in part 2 of the survey instrument were collapsed into the five major dependent variables.

Table 1 Survey Statements Representative of NCTM Process Standards and Traditional Strategies

Process Standard	Statement (Numbered Order)
Problem Solving	1, 12, 18, 24, 29, 31, 41
Reasoning & Proof	2, 10, 16, 22, 27, 32, 37
Communication	6, 7, 13, 19, 30, 34, 36, 40
Connections	5, 9, 15, 21, 26, 33, 35
Representation	4, 8, 14, 20, 25, 39
Traditional	3, 11, 17, 23, 28

Participants were asked to provide the amount of time they spent planning per week in minutes both at home and school. Planning was defined as time spent planning for instruction or reflecting on prior instruction, not time spent grading papers or completing administrative tasks. Responses indicated that the mean of the individual planning times was 346.38 minutes per week. Although there was a large reported planning time of 2000 minutes that may skew the mean, the median of the times was 300 minutes which is fairly consistent with the mean. Therefore, the average amount of time spent individually planning for instruction was about 5 to 6 hours per week. The mean of the collaborative planning time was 43.63 minutes per week. What is most notable about the collaborative planning times is that the most reported time was 0 minutes per week (67 responses) signifying that nearly 28% of the respondents did not plan collaboratively at all. Comments by some of the participants represented both ends of the spectrum with respect to planning. Some teachers indicated that they spent a lot of time planning especially at the start of a chapter or semester while others indicated that they had very little time to plan for instruction. Table 2 provides a descriptive analysis of the reported individual and collaborative planning times.

Table 2 Descriptive Statistics of Independent Variables

	Individual Planning Time (minutes per week)	Collaborative Planning Time (minutes per week)
Respondents	229	228
Non-Respondents	14	15
Mean	346.38	43.63
Median	300.00	20.00
Mode	300	0
Std. Deviation	257.64	79.72
Minimum	10	0
Maximum	2000	675

Participants were asked to use a Likert scale to choose the best value for the frequency of use of a list of instructional strategies. The instructional strategies came from authors who support NCTM recommended practices (Artzt & Armour-Thomas, 1999; Carpenter & Lehrer, 1999; D'Ambrosio et al., 2004; Maccini & Gagnon, 2000; Stigler & Hiebert, 2004). The rating scale for this part of the instrument was as follows: 1 = "never", 2 = "rarely", 3 = "occasionally", 4 = "frequently", and 5 = "daily". First of all, a mean frequency score was calculated for each respondent for each respondent and called the mean NCTM score. The mean NCTM scores refer to how often all of the NCTM recommended strategies were utilized by the respondent. Additionally, mean frequency scores were calculated with respect to each of the process standards. The overall mean frequency score for the instructional strategies was 3.41 which can be interpreted as a frequency of occasionally, or 1 or 2 times per month. The means of all of the groups of instructional strategies with the exception of communication are 3+ also indicating an occasional occurrence. The mean frequency score for the strategies that define communication was 2.96, slightly less than the other process standards.

The different planning times that were reported were divided into four quartiles based on the reported times. Quartiles were not based on the number of participants. The reported planning times were listed in ascending order with each different time listed only once. The times were then divided into four approximately equal groups. The four equal groups of reported planning times did not necessarily result in four quartiles of equal length. If a respondent did not report a planning time, that respondent was listed as a non-respondent. The first quartile of individual planning times ranged from 0 to 160 minutes per week; the second quartile ranged from 161 to 345 minutes per week, the third quartile ranged from 346 to 595 minutes per week, and the fourth quartile ranged from 596 to 2000 minutes per week. The first quartile of collaborative planning times ranged from 0 to 15 minutes per week; the second quartile ranged from 16 to 59 minutes per week, the third quartile ranged from 60 to 180 minutes per week, and the fourth quartile ranged from 181 to 675 minutes per week. Table 3 provides a descriptive analysis of the quartiles of individual and collaborative planning times.

Table 3 Descriptive Statistics of Planning Time Quartiles

Individual Planning Times	Time in Minutes Per Week	Number of Responses	Mean use of NCTM Instructional Strategies	Standard Deviation
Quartile 1	0-160	63	3.22	.436
Quartile 2	161-345	74	3.36	.447
Quartile 3	346-595	57	3.45	.438
Quartile 4	596-2000	35	3.72	.450
Collaborative Planning Times				
Quartile 1	0-15	110	3.33	.442
Quartile 2	16-59	53	3.37	.364
Quartile 3	60-180	55	3.53	.571
Quartile 4	181-675	10	3.73	.408

The following segments illustrate the major findings of the study through analyses of each research question. To address the research questions, a One-Way Analysis of Variance (ANOVA) was used. This test was selected because of the multitude of factors associated with the quartiles of the independent variables and the mean frequency scores of the dependent variables. An ANOVA test can detect significant statistical differences between each of the groups. It is a robust test that helps reduce the possibility of Type I errors. In addition, an ANOVA is appropriate if certain assumptions are met: the populations must be normally or approximately normally distributed, the samples must be independent of each other, and the variances of the populations must be equal (Bluman, 2007). The data obtained in this study met those assumptions. Statistical significance is achieved at $p < .05$. Furthermore, according to Norusis (2006), a significance level of .000 does not mean 0; it means that the "observed significance level is less than .0005" (p. 240).

After One-Way ANOVA tests were conducted, Fisher's Least Significant Difference (LSD) multiple comparisons tests were conducted to determine exactly where the differences occurred. Fisher's LSD test is one of the most commonly used multiple comparison tests (Dallal, 2001). The Bonferroni test, another multiple comparison test, tends to push values to non-significance (SAS/STAT User's Guide, 1999), but was also utilized by the researcher to help support results of the Fisher's LSD test.

Research Question 1: What differences exist in the perceived mean frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of individual planning time?

Null Hypothesis 1: There is no difference in the mean frequency of use of various strands of instructional strategies as related to the individual planning times of high school Algebra 1 and Applied Math teachers.

Based on the results of ANOVA testing, there was a statistically significant difference between the mean frequency of use of NCTM instructional strategies in relation to the amount of time spent in individual planning. Therefore, the researcher rejects the null hypothesis for research question one. The F ratio was 9.910 yielding a significance of .000. The teachers who planned the most used significantly more NCTM process standard strategies. Table 4 refers to a comparison of mean frequencies for the NCTM recommended strategies grouped by quartiles of individual planning time. The table illustrates the results of a One-Way ANOVA comparing the frequencies by time; significance occurred at the $p < .05$ level indicating that differences do occur between the mean frequencies of NCTM recommended strategies based on length of individual planning times.

Table 4 ANOVA for Mean Frequency of NCTM Instructional Strategies based on Quartiles of Individual Planning Time

	Mean Square	F	Significance
Between groups	5.817	9.910	.000
Within groups	44.028		

Significance at $p < .05$

Fisher's LSD test indicated statistical significance between the fourth quartile and each of the first three quartiles of time. In addition, a significant difference existed between the first and third quartiles of time. There were no significant differences between the other quartiles of time. Furthermore, the more conservative Bonferroni multiple comparisons test was run and resulted in the same areas of significance. In summary, the mean frequency scores of the respondents who devoted extensive time to planning differed significantly from those who planned in lesser amounts of time. Table 5 displays precisely in which quartiles the significant differences occurred based on the Fisher's LSD multiple comparisons test. See Appendix G for the complete multiple comparisons test results.

Table 5 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Instructional Strategies based on Quartiles of Individual Planning Time

Quartiles for Individual Planning Times (I)	Quartiles for Individual Planning Times (J)	Mean Difference (I – J)	Significance
1st Quartile	3rd Quartile	-.22911	.005
4th Quartile	1st Quartile	.49593	.000
4th Quartile	2nd Quartile	.36065	.000
4th Quartile	3rd Quartile	.26682	.005

Significance at $p < .05$

In order to better understand major findings, the researcher conducted One-Way ANOVAs to determine if differences existed in the mean frequency of specific groups of NCTM process standards. The mean frequencies of the NCTM five process standards were compared with respect to quartiles of individual planning times. The F ratios for all five NCTM process standards showed significance. Therefore, the mean frequency scores of the respondents who planned infrequently differed significantly from those who devoted extensive time to planning with respect to all of the NCTM recommended process standards. Table 6 displays results of a One-Way ANOVA comparing the NCTM process standards and a set of traditional strategies with respect to the quartiles of individual planning time.

Table 6	ANOVA for Mean Frequency of NCTM Process Standards and Traditional Strategies based on Quartiles of Individual Planning Time			
		Mean Square	F	Significance
Problem Solving	Between	2.233	9.448	.000
	Within Groups	.236		
Reasoning & Proof	Between	1.980	7.922	.000
	Within Groups	.250		
Communication	Between	2.957	9.655	.000
	Within Groups	.306		
Connections	Between	.837	2.887	.036
	Within Groups	.290		
Representation	Between	2.352	7.669	.000
	Within Groups	.307		
Traditional	Between	.146	.457	.713
	Within Groups	.320		

Significance at $p < .05$

Multiple comparisons testing indicated significance in several areas. In the problem solving set of strategies, the mean frequencies of teachers in the fourth quartile were significantly different than those of teachers in the first three quartiles. In addition, the first quartile scores were significantly different than the third quartile scores. The reasoning and proof scores showed similar results. Scores in the fourth quartile differed significantly from those in the first three quartiles, and the scores in the first quartile differed significantly from those in the second and third quartiles. The communication strategies also showed several areas of significance. There was a significant difference between the fourth quartile and the first three quartiles and between the first and third quartiles. The connections area showed significance only between the first and fourth quartiles and between the second and fourth quartiles. The representation process standard showed significance between the first and third quartiles, the first and fourth quartiles, the second and third quartiles, and the second and fourth quartiles. Bonferroni's test confirmed the same significant differences in the problem solving scores and in two-thirds of the remaining areas that Fisher's LSD test identified. In conclusion, the problem solving, reasoning and proof, communication, connections, and representation practices of those who planned in the lower quartiles of time differ significantly from those who planned in the upper quartiles of time. Table 7 reports the areas that had significant differences found by Fisher's LSD multiple comparisons test. A complete table may be found in Appendix G.

Table 7 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Process Standards based on Quartiles of Individual Planning Time

Dependent Variable	Quartiles for Individual Planning Times (I)	Quartiles for Individual Planning Times (J)	Mean Difference (I – J)	Significance
Problem Solving	1st Quartile	3rd Quartile	-.24892	.006
	4th Quartile	1st Quartile	.53539	.000
	4th Quartile	2nd Quartile	.37392	.000
	4th Quartile	3rd Quartile	.28647	.007
Reasoning & Proof	1st Quartile	2nd Quartile	-.19907	.021
	1st Quartile	3rd Quartile	-.20695	.024
	4th Quartile	1st Quartile	.51279	.000
	4th Quartile	2nd Quartile	.31372	.002
	4th Quartile	3rd Quartile	.30584	.005
Communication	4th Quartile	1st Quartile	.61833	.000
	4th Quartile	2nd Quartile	.44070	.000
	4th Quartile	3rd Quartile	.34928	.004
	1st Quartile	3rd Quartile	-.26905	.008
Connections	4th Quartile	1st Quartile	.31758	.006
	4th Quartile	2nd Quartile	.27609	.013
Representation	3rd Quartile	1st Quartile	.31395	.002
	3rd Quartile	2nd Quartile	.21721	.027
	4th Quartile	1st Quartile	.49556	.000
	4th Quartile	2nd Quartile	.39882	.001

Significance at $p < .05$

Research Question 2: What differences exist in the perceived mean frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of collaborative planning time?

Null Hypothesis 2: There is no difference in the mean frequency of use of various strands of instructional strategies as related to the collaborative planning times of high school Algebra 1 and Applied Math teachers.

Based on the results of ANOVA testing, there was a statistically significant difference between the mean frequency of use of NCTM instructional strategies in relation to the amount of time spent in collaborative planning. Therefore, the researcher rejects the null hypothesis for research question 2. The F ratio was 4.124 yielding a significance of .007. The teachers who planned the most used significantly more NCTM process standard strategies. Table 8 illustrates the results of a One-Way ANOVA comparing overall mean frequency scores of NCTM instructional strategies based upon differences in collaborative planning times.

Table 8 ANOVA for Mean Frequency of NCTM Instructional Strategies based on Quartiles of Collaborative Planning Time

	Mean Square	F	Significance
Between groups	0.870	4.124	.007
Within groups	0.211		

Significance at $p < .05$

Fisher's LSD test indicated statistical significance between the first and third quartiles and between the first and fourth quartiles of time. There were also significant differences between the second and fourth quartiles. There were no significant differences between the other quartiles of time. The Bonferroni test confirmed one of the three significant areas in the Fisher's LSD test. To summarize, the mean NCTM scores of the respondents who planned infrequently differed significantly from those who devoted extensive time to collaborative planning. Table 9 displays the significant results of the Fisher's LSD multiple comparisons test. See Appendix G for a detailed table of the Fisher's LSD test.

Table 9 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Instructional Strategies based on Quartiles of Collaborative Planning Time

Quartiles for Collaborative Planning Times (I)	Quartiles for Collaborative Planning Times (J)	Mean Difference (I – J)	Significance
4th Quartile	1st Quartile	.40150	.009
4th Quartile	2nd Quartile	.35202	.027
3rd Quartile	1st Quartile	.20244	.008

Significance at $p < .05$

In order to explain the results in greater detail, the researcher conducted One-Way ANOVAs to determine if differences existed in the mean frequency of specific groups of instructional strategies. The mean frequencies of the NCTM five process standards were compared with respect to quartiles of collaborative planning times. Just as with the individual planning times, the F ratios for all of the NCTM process standards showed significance. Table 10 displays results of a One-Way ANOVA comparing groups of instructional strategies with respect to the amount of collaborative planning time.

Table 10 ANOVA for Mean Frequency of NCTM Process Standards and Traditional Strategies based on Quartiles of Collaborative Planning Time

		Mean Square	F	Significance
Problem Solving	Between Groups	.851	3.317	.021
	Within Groups	.257		
Reasoning & Proof	Between Groups	.760	2.864	.038
	Within Groups	.265		
Communication	Between Groups	1.371	4.177	.007
	Within Groups	.328		
Connections	Between Groups	.891	3.074	.029
	Within Groups	.290		
Representation	Between Groups	.890	2.728	.045
	Within Groups	.326		
Traditional	Between Groups	.273	.856	.465
	Within Groups	.319		

Significance at $p < .05$

Multiple comparisons testing indicated significance in several areas. In the problem solving set of strategies, the mean frequencies of teachers in the first quartile were significantly different than those of teachers in the third and fourth quartiles. The reasoning and proof standard only had one significant difference in scores which occurred between the first and fourth quartiles of time. The communication strategies indicated the most areas of significance for collaborative planning times. Differences occurred between the first and third quartiles, first and fourth quartiles, second and third quartiles, and second and fourth quartiles. The connection scores showed significant differences between the first and third quartiles and the first and fourth quartiles. Finally, the representation area showed a significance difference between the first and third quartiles. Once again, significant differences occurred between the least amounts of reported collaborative planning time and the most amounts. Table 11 gives the significant results of Fisher's LSD multiple comparisons test. See Appendix G for a detailed table.

Table 11 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Process Standards based on Quartiles of Collaborative Planning Time

Dependent Variable	Quartiles for Collaborative Planning Times (I)	Quartiles for Collaborative Planning Times (J)	Mean Difference (I – J)	Significance
Problem Solving	1^{st} Quartile	3^{rd} Quartile	-.20316	.016
	1^{st} Quartile	4^{th} Quartile	-.38896	.021
Reasoning & Proof	1^{st} Quartile	4^{th} Quartile	-.44351	.010
Communications	3^{rd} Quartile	1^{st} Quartile	.26585	.005
	3^{rd} Quartile	2^{nd} Quartile	.28759	.010
	4^{th} Quartile	1^{st} Quartile	.39069	.040
	4^{th} Quartile	2^{nd} Quartile	.41243	.038
Connections	1^{st} Quartile	3^{rd} Quartile	-.19970	.026
	1^{st} Quartile	4^{th} Quartile	-.42221	.018
Representation	1^{st} Quartile	3^{rd} Quartile	-.19697	.038

Significance at $p < .05$

Ancillary Findings

In addition to the major findings, there were several subsequent findings that were of interest. The demographics portion of the survey allowed the researcher to attempt to develop a description of the West Virginia high school mathematics teacher with respect to planning. The researcher attempted to answer the following questions in order to gain better understanding of characteristics that may affect planning habits or NCTM instructional scores:

Ancillary Question 1: Do the planning habits of the respondents differ based on any of their demographic characteristics?

Ancillary Question 2: Does the mean NCTM score or mean scores for the process standards of the respondents differ based on any of their demographic characteristics?

Ancillary Question 3: How do the respondents score on a set of traditional instructional strategies and does their use of traditional strategies differ based on their planning habits?

Overall Demographic Characteristics

Participants were asked to identify their gender, age, years experience as a teacher, years experience as a math teacher, and highest degree earned. In addition, the respondents were asked if they held membership in any math organizations and if they had attended a professional conference in the last two years. The data were recorded as nominal data in categories. A general analysis of the descriptive data indicated that out of 243 responses, two ages, one teaching experience, five math teaching experience, and one conference attendance data were left out.

A majority of the respondents were female (68.3%) while the remaining 31.7% were male. The survey gave respondents five age categories to choose from, each in ten year intervals. Over three-fourths of the respondents were 30 to 59 years of age. The teaching experience and math teaching experience of the respondents were originally divided into eight groups; however, the groups were collapsed into four ten-year groups to provide more responses per experience group. The teaching experience of the respondents was fairly evenly distributed among the three groups up to 30 years. The math teaching experience of the respondents was more heavily distributed at the lesser end indicating that many of the teachers started teaching math after they began teaching. Half of the respondents (49.9%) had been teaching math less than ten years. The final demographic characteristic is that of highest degree earned. A majority of the respondents held master's degrees (55.6%) while many others held bachelor's degrees (43.6%). Only 0.4% held an education specialist certification or a doctorate degree. Almost one third (31.3%) of the respondents were members of either the NCTM or its affiliates at the state or county level. Almost two-thirds (62.4%) of the respondents had attended a professional conference within the last two years

In general, the largest group of West Virginia high school math teachers was female, between the ages of 30 and 60, and had master's degrees. While their overall, teaching experience was equally spread among all experience groups, most of the respondents had only taught math for ten years or less. Attendance at professional conferences was also widespread.

Planning Habits based on Demographic Characteristics

Ancillary Question 1: Do the planning habits of the respondents differ based on any of their demographic characteristics?

To determine if significant differences occurred between the demographic variables and the individual and collaborative planning habits of the respondents, initially, one-way ANOVA tests along with Fisher's LSD multiple comparisons test were run on the data. If no significance occurred, the data were collapsed and independent t-tests were completed. Several areas of significance were revealed after statistical analysis.

First of all, significant differences occurred between the quartiles of individual planning times with respect to age. The differences occurred specifically between respondents in their 20s (M = 1.95) and 50s (M = 2.56) and between respondents in their 30s (M = 2.09) and 50s (M = 2.56). Similar results were found regarding the math teaching experience of the respondents. The differences occurred specifically between respondents who had taught math less than 10 years (M = 2.12) and those who had taught math 10 to 20 years (M = 2.47) and between those who had taught math less than 10 years (M = 2.12) and those who had taught math for over 30 years (M = 2.70). In summary, the older teachers individually planned longer than the younger ones and those with the most experience teaching math individually planned longer than those with the least experience, with the exception of the 10-19 year group who planned longer then the 20-29 year group. Table 12 displays the results of the ANOVA tests for age and math teaching experience groups. Table 13 and Table 14 present the significant portions of the Fisher's LSD test on the age and math teaching experience groups. The complete LSD test results may be found in Appendix G.

Table 12 ANOVA for Quartiles of Individual Planning Time based on Age and Math Teaching Experience

		Mean Square	F	Significance
Age	Between Groups	2.907	2.857	.024
	Within Groups	1.018		
Math Teaching Experience	Between Groups	2.841	2.757	.043
	Within Groups	1.031		

Significance at $p < .05$

Table 13 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Individual Planning Time based on Age

Dependent Variable	Age (I)	Age (J)	Mean Difference (I – J)	Significance
Quartiles for Individual Planning Times	20-29	50-59	-.610	.003
	30-39	50-59	-.465	.012

Significance at $p < .05$

Table 14 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Individual Planning Time based on Math Teaching Experience

Dependent Variable	Math Teaching Experience (I)	Math Teaching Experience (J)	Mean Difference (I – J)	Significance
Quartiles for Individual Planning Times	0-9	10-19	-.352	.042
	0-9	30+	-.582	.018

Significance at $p < .05$

Significant differences also occurred in the quartiles of collaborative planning times based on math teaching experience. However, the results are inverse from those of individual planning times; the means decrease as the experience increases. The mean quartile of collaborative planning time of teachers with over 30 years experience ($M = 1.30$) was significantly less than all of the other experience groups. Table 15 displays the ANOVA test, and Table 16 displays the significant portions of the Fisher's LSD test. See Appendix G for the details of Table 16.

Table 15 ANOVA for Quartiles of Collaborative Planning Time based on Math Teaching Experience

		Mean Square	F	Significance
Math Teaching Experience	Between Groups	2.350	2.723	.045
	Within Groups	.863		

Significance at $p < .05$

Table 16 Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Collaborative Planning Time based on Math Teaching Experience

Dependent Variable	Math Teaching Experience (I)	Math Teaching Experience (J)	Mean Difference (I – J)	Significance
Quartiles for Collaborative Planning Times	0-9	30+	.640	.005
	10-19	30+	.540	.029
	20-29	30+	.592	.023

Significance at $p < .05$

Initially, ANOVA tests revealed no differences in planning quartiles with respect to the teaching experience of the respondents. See Table 17 and Table 18 in Appendix G for results of the ANOVA tests. However, the groups were collapsed into two groups as defined by the West Virginia Teacher Evaluation Form: those who have taught for less than five years and those who have taught for five years or more. Independent t-tests revealed significant differences in the quartiles of individual planning times of the teachers in the two experience groups. The novice teachers ($M = 2.05$), or those who have taught for less than 5 years, planned significantly less than those who had been teaching for over five years (M = 2.39). Table 19 displays the results of the independent t-test.

Table 19 Independent T-Test for Significant Differences between Quartiles of Individual Planning Times based on WVDE Teaching Experience

			t-test for Equality of Means		
		F	t	Significance (2-tailed)	Mean Difference
Quartiles of Individual Planning Times	Equal Variances Assumed	5.462	-2.317	.021	-.336
	Equal Variances Not Assumed		-2.390	.018	-.336

Significance at $p < .05$

The independent t-test comparing collaborative planning time based on West Virginia's definition of teaching experience resulted in non-significance. Table 20 in Appendix G details the results of the independent t-test comparing collaborative planning times based on teaching experience.

Statistical tests were also performed on the reported planning times and the quartiles of planning times with respect to the demographic variables of highest degree completed and recent conference attended. ANOVA tests resulted in non-significant results, thus indicating that planning times did not differ based on having a graduate degree or undergraduate degree and based on recently attending a conference or not. Independent t-tests were not completed since only two groups at a time were being compared in the ANOVA tests. See Table 21 and Table 22 in Appendix G for details of ANOVA results.

NCTM Scores based on Demographic Characteristics

Ancillary Question 2: Does the mean NCTM score or mean scores for the process standards of the respondents differ based on any of their demographic characteristics?

To determine if significant differences occurred between the demographic classifications and the overall mean NCTM score as well as the mean scores for each process standard, one-way ANOVA tests along with the Fisher's LSD multiple comparisons test were run on the data. The ANOVA tests found only one area of significance: the mean NCTM scores of those who had attended a professional conference in the last two years differed from those who had not. More specifically, the ANOVA test revealed significant values for all process standards, except representation, with respect to conference attendance. No Fisher's LSD Test could be run because there were less than three groups. Table 23 displays the results of the ANOVA test comparing the mean NCTM and process standard scores based on recent conference attendance.

Table 23 ANOVA for Mean NCTM and Process Standard Scores based on Recent Conference Attendance

		Mean Square	F	Significance
Mean NCTM	Between Groups	1.385	6.472	.012
	Within Groups	.214		
Problem Solving	Between Groups	1.013	3.989	.047
	Within Groups	.254		
Reasoning & Proof	Between Groups	1.853	6.904	.009
	Within Groups	.268		
Communication	Between Groups	1.887	5.724	.018
	Within Groups	.330		
Connections	Between Groups	1.265	4.200	.042
	Within Groups	.301		

Significance at $p < .05$

To further investigate the relationship between the demographic variables and the NCTM scores, the researcher first completed ANOVA tests and then independent t-tests after the ANOVAs failed to yield significance and the groups had either been collapsed into two categories or by comparing two groups at a time. The t-tests yielded some significant results.

The age of the respondent influenced NCTM scores in two areas. First of all, teachers who were 30-39 years old (M = 3.37) scored differently from those who were 50-59 years old (M = 3.57) on their representation scores. The older teachers scored higher. Table 24 shows the results of the independent t-test comparing means of the two age groups.

Table 24 Independent T-Test for Significant Differences between Process Standards of Age Groups 30-39 and 50-59

			t-test for Equality of Means		
		F	t	Significance (2-tailed)	Mean Difference
Quartiles of Individual Planning Times	Equal Variances Assumed	2.954	-2.141	.034	-.20367
	Equal Variances Not Assumed		-2.248	.026	-.20367

Significance at $p < .05$

In addition, teachers who were 40-49 years old scored differently from some of the older counterparts. The teachers in their 40s (M = 3.29 and M = 3.24) scored significantly lower than those who were in their 50s (M = 3.46 and M = 3.48) on the overall mean NCTM score and problem solving process standard score. Table 25 displays the results of comparing teachers in their 40s to teachers in their 50s with respect to the NCTM standards.

Table 25 Independent T-Test for Significant Differences between Mean NCTM and Process Standards of Age Groups 40-49 and 50-59

		F	t	t-test for Equality of Means Significance (2-tailed)	Mean Difference
Mean NCTM Scores	Equal Variances Assumed	.031	-2.037	.044	-.16306
	Equal Variances Not Assumed		-2.035	.044	-.16306
Problem Solving	Equal Variances Assumed	5.4638	-2.754	.007	-.23164
	Equal Variances Not Assumed		-2.739	.007	-.23164

Significance at $p < .05$

Table 26 in Appendix G details the results of the ANOVA test comparing NCTM scores based on age groups which resulted in non-significance. While Table 25 reports the significant results, Table 27 in Appendix G summarizes all of the results of the independent t-tests comparing NCTM scores based on age groups compared two at a time.

NCTM scores were also examined with respect to teaching experience and math teaching experience. Although some of the p-values were low, none resulted in significant differences at the .05 level. See Table 28 through Table 31 in Appendix G for ANOVA and t-test results when NCTM scores were examined with respect to teaching experience and math teaching experience.

In summary, some links were found to exist between the demographic variables of age and recent conference attendance and the NCTM scores of the respondents.

Planning Habits and Traditional Instructional Practices

Ancillary Question 3: How do the respondents score on a set of traditional instructional strategies and does their use of traditional strategies differ based on their planning habits?

The main recommendation of the NCTM is the development of conceptual understanding of mathematics through an inquiry approach to teaching and learning that influences students' meaningful learning of mathematics rather than a procedural understanding through memorization and drill/practice (D'Ambrosio et al., 2004). Suggested strategies included use of cooperative learning, use of evidence to verify results, use of conjecturing, inventing, and problem solving rather than mechanical computations, and use of real life situations to make connections from mathematics to other areas (Schroeder, 1991). Traditional methods of instruction such as drill and practice with pencil-and-paper, memorization of rules and algorithms, and note-taking from lectures were de-emphasized (Klein, 2003; NCTM, 1995). The NCTM standards described effective learning of math as investigating, conjecturing, reasoning, and reflecting rather than memorizing and repeating. Traditional teaching methods were discouraged while reform methods were stressed (Klein, 2003; NCTM, 1995).

Part 2 of the *Mathematics Instructional Practices Survey* asked respondents to choose the frequency they use various instructional strategies. Most of the strategies were NCTM recommended and could be designated as one of the process standards of problem solving, reasoning and proof, communications, connections, and representation. However, the researcher recognizes that some math teachers utilize a traditional repertoire of strategies; therefore, traditional strategies were included on the survey. A mean score for the set of traditional strategies was calculated for each respondent. The overall mean of the traditional strategies was 3.53 with a standard deviation of .565. To determine if significant differences occurred between the reported planning times and the mean of the traditional strategies, one-way ANOVA tests along with the Fisher's LSD multiple comparisons test were run on the data. No significance resulted from the tests so the amount of time spent planning individually and collaboratively did not affect the frequency of use of traditional instructional strategies. An ANOVA test was also performed on the traditional strategies based on demographic groups. Only one area of significance was found. The teachers in their 20s (M = 3.72) used significantly more traditional strategies than their counterparts in their 50s (M = 3.41). Table 32 displays the significant results of comparing the use of traditional instructional strategies of teachers in the two groups. See Table 26 through Table 31 in Appendix G for detailed results of the ANOVA and t-tests examining traditional strategies based on age, teaching experience, and math teaching experience.

Table 32 Independent T-Test for Significant Differences between use of Traditional Strategies by Age Groups 20-29 and 50-59

				t-test for Equality of Means	
		F	t	Significance (2-tailed)	Mean Difference
Traditional Strategies	Equal Variances Assumed	2.627	2.735	.007	.31565
	Equal Variances Not Assumed		2.985	.004	.31565

Significance at $p < .05$

Summary

This chapter presented the statistical analyses of the data collected from the *Mathematics Instructional Practices Survey*, a researcher-designed survey of the population of West Virginia Algebra 1 and Applied Math 1 & 2 teachers in grades 9-12. The quantitative instrument was created through an in-depth review of the literature on effective instructional practices for mathematics, and was designed to measure the length of planning times of the respondents as well as their frequency of use of the instructional practices. Two-hundred forty-three respondents participated in the study, representing a 50.83% response rate of the population.

The *Mathematics Instructional Practices Survey* utilized an open-ended section to record planning habits of the respondents and a Likert scale to ascertain the frequency of use of several instructional practices. Descriptive statistics were calculated for the independent and dependent variables. Tests of significance assessed whether there were any relationships among the variables and demographic data.

Statistical analyses revealed that there were significant differences in the mean frequency of use of the instructional strategies based on the quartiles of individual planning times reported by the teachers. Multiple comparison tests indicated that significant differences occurred between the teachers who planned the longest (fourth quartile) and all other respondents and between those in the first and third quartiles. More detailed analyses revealed that significant differences occurred among some of the quartiles of individual planning time with respect to the NCTM process standards of problem solving, reasoning and proof, communication, connections, and representation.

Statistical analyses revealed that there were significant differences in the mean frequency of use of the instructional strategies based on the quartile of collaborative planning times reported by the teachers. Multiple comparisons tests indicated that significant differences occurred between the first and third quartiles, first and fourth quartiles, and second and fourth quartiles. More detailed analyses revealed that significant differences occurred among some of the quartiles of collaborative planning time with respect to the NCTM process standards of problem solving, reasoning and proof, communication, connections, and representation.

Ancillary findings suggested relationships between demographic variables and planning habits of respondents. Significance was found between the variables of quartiles of individual planning time and age, quartiles of individual and collaborative planning time and math teaching experience, quartiles of individual planning time and teaching experience. In addition, significant differences were found between the demographic variables and the NCTM scores of the respondents in the areas of age and recent conference attendance. Significance was found in mean scores for traditional instructional practices with respect to age.

Respondents were given the opportunity to write comments in an open-ended section of the survey. Several trends were revealed in the comments. Over 30% of the respondents stated that they planned at home, and 25% of the comments reported that there wasn't enough time at school to adequately plan for lessons usually because of the number of different class preps that the teacher had or the many duties that he had. Additionally, 28% of the respondents reported that they didn't collaborate with other teachers during the school day or outside of school; however, 17% reported that they would like to either have collaborative planning time at school or more collaborative planning time at school. Finally, many teachers described the planning activities or instructional activities that they were involved in such as the use of internet resources, the Cognitive Tutor Algebra program, and Algebraic Thinking toolkit.

CHAPTER FIVE: CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Best practices are literature based instructional practices that are espoused in the literature as critical to student and school success. However, best practices cannot be assimilated into a teacher's repertoire of strategies overnight. As Alperin (2001) reported, it takes at least 50 hours of instruction and practice for a teacher to become comfortable with a new instructional technique. This time can be attained partially through careful planning both individually and collaboratively. The purpose of this chapter is to present the conclusions regarding the frequency of use of National Council of Teachers of Mathematics (NCTM) recommended practices with respect to the amount of reported individual and collaborative planning times which were gathered from the administration of the *Mathematics Instructional Practices Survey*. Recommendations for further study derived from the findings and conclusions of the *Mathematics Instructional Practices Survey* are also presented.

Purpose of the Study

The purpose of this study was to determine whether the amount of time a high school Applied Math or Algebra 1 teacher spent planning, individually or collaboratively, affected the frequency of utilization of NCTM recommended practices. The study also investigated the differences in planning times and use of strategies based on the following demographic variables: gender, age, teaching experience, math teaching experience, highest degree earned, and recent conference attendance. Two main research questions and three ancillary questions were addressed. Findings indicated that the amount of time a teacher spent planning, individually or collaboratively, did significantly impact the mean frequency of use of NCTM recommended instructional practices. Furthermore, various demographic variables impacted planning times and NCTM scores.

Description of the Population

The population of this study consisted of all West Virginia high school Algebra 1 and Applied Math teachers. The population was provided by the West Virginia Department of Education databank. The entire population was asked to complete the *Mathematics Instructional Practices Survey*. Of the 478 participants, 243 returned the survey. The response rate was 50.83% of the overall number of participants.

Research Design and Procedures

This study utilized a non-experimental, quantitative design method to examine differences between frequency of use of NCTM recommended instructional practices based on individual and collaborative planning times. Descriptive in nature, the study utilized a researcher-designed survey of the entire population of high school Algebra 1 and Applied Math 1 and 2 teachers.

The instrument in this study, a cross-sectional survey titled the *Mathematics Instructional Practices Survey*, asked participants to report their individual and collaborative planning times in minutes per week. Planning times were defined as time spent planning for instruction or reflecting on previously taught lessons. In addition, the participants were asked to record their frequency of use of specific instructional strategies using a 5-point Likert scale (5 = daily, 4 = frequently, 3 = occasionally, 2 = rarely, and 1 = never). Finally, demographic data on gender, age, teaching experience, math teaching experience, highest degree earned, and recent conference attendance were obtained from the *Mathematics Instructional Practices Survey*.

Analyses of data collected from the study consisted of the use of descriptive statistics for measures of both central tendency and variation as well as testing of hypotheses. Descriptive statistics of mean, median, mode, and standard deviation helped provide a picture of the variables such as planning times and frequency scores for each NCTM process standard based on quartiles of planning times.

An Analysis of Variance (ANOVA) test was utilized to determine if differences existed between mean frequency scores of the instructional practices grouped by quartiles of planning time, differences in planning times based on demographic variables, and differences between mean frequency scores of the instructional practices grouped by demographic variables. The Fisher's Least Significant Difference (LSD) multiple comparisons test was utilized to pinpoint exactly where the differences occurred. If ANOVA tests failed to yield significance among groups, independent t-tests were utilized to identify differences between two groups at a time. A probability value (p) was obtained for each statistical test indicating the exact significance of the relationship between the independent variable and dependent variable. An alpha level of .05 was used as the level of significance for this study.

Findings and Conclusions

The following findings and conclusions are based upon a statistical testing of the null hypothesis of each research question. The conclusions are most applicable to high school Algebra 1 and Applied Math teachers in the state of West Virginia; however, they may also be applicable to teachers outside of West Virginia that base their instruction on the standards recommended by the NCTM. The conclusions are also strengthened by the design of the study: sampling error was eliminated since the entire population of high school regular education Algebra 1 and Applied Math teachers in West Virginia was surveyed.

Individual and Collaborative Planning

Instructional planning has been an emphasis in education for many years. Contemporary models of planning have emerged that emphasize teacher practices of self-monitoring, meeting the developmental needs of the students, and assigning work that aids students in making connections between new and previous knowledge (Baylor & Kitsantas, 2001; Panasuk et al., 2002). National and local educational entities make recommendations about instructional planning as a means to improve practice (Blank, 2004; Peterson & Bond, 2004; NBPTS, 2000; WVBOE, 2006). Instructional planning contributes to a more student-centered instructional approach, use of a greater variety of instructional strategies, lessons that promote better thinking skills, and the sharing of ideas among teachers (An, 2001; Burns & Reis, 1991; Decker, 2000; Martin, 2001; Welch, 2000). More specifically, Adajian (1996) determined that collaborative planning resulted in higher levels of reformed mathematics instruction. Nevertheless, it is difficult to adhere to the latest planning recommendations without ample planning time. In fact, time was declared as critical to education reform efforts in the United States (Viale, 2005) and that an increase in planning time is more important for improving instruction than an increase in instructional time (Livingston, 1994).

NCTM Process Standards

The NCTM is one national organization that stresses the importance of instructional planning. In 2000, Lee V. Stiff, the NCTM president, urged renewed attention to good lesson planning and lesson implementation in order to improve mathematics learning (Panasuk et al., 2002). Furthermore, the NCTM asserts that "opportunities to reflect and refine instructional practice are crucial" (*Principles and* Standards, 2000, p. 19). *Principles and Standards* (2000), the latest standards document developed by the NCTM, puts forth the organization's recommendations on achieving quality mathematics education for all students. The recommendations contain a set of process standards that guide instructional practices of teachers. The process standards describe ways that students should acquire and use content knowledge and consist of problem solving, reasoning and proof, communication, connections, and representation strands.

The following research questions of this study were posed in relation to the information revealed in the literature about planning practices and their importance with respect to the NCTM process standards. In addition, conclusions are made from the statistical analysis of the data corresponding to each question.

Research Question 1

What differences exist in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of individual planning time?

Analysis of the data revealed that statistical differences did occur in the mean frequency of use of NCTM recommended instructional practices among the groups of teachers in different quartiles of individual planning time. There was a significant difference in the use of the NCTM process standards between those who planned longer, as evidenced by the teachers in the top two quartiles, and those who planned less frequently, as evidenced by the teachers in the lower two quartiles. As a result, it can be concluded that teachers who use NCTM recommended strategies less frequently are those who plan the least and those who use NCTM recommended strategies more frequently are those who plan the most. This finding agrees with those of An (2001), Banbury (1998), Holshen (2000), and Quinn (1998) who all found that longer planning contributes to a more student-centered instructional approach in mathematics. Consequently, the NCTM describes its process standards as more student-centered than traditional instruction (Burrill, 1997; D'Ambrosio et al., 2004; Willoughby, 1988).

It has been shown in the literature that many teachers individually plan at home, so it is interesting to note that over 30% of the respondents reported their own instructional planning took place at home. This finding concurs with results of Pitler's (1997) and Wolf's (2003) studies who ascertained that true instructional planning takes place at home and for as much as five hours on the weekends.

Additionally, 25% of the comments received in this study indicated that the respondents did not have enough individual planning time at school. Thus it can be concluded that those who planned the longest did so outside of the school environment. This outcome supports the findings of Erickson (1993) who cited short preparation times as an impediment to implementing standards-based instructional practices and Viale

(2005) who stated that standards-based instruction benefits from an increase in independent daily planning. Teachers in other studies (Alperin, 2001; Decker, 2000; Livingston, 1994; Robbins, 1993; Wolf, 2003) also reported that more planning time was needed.

In looking at the specific NCTM strategies as divided into the five process standards of problem solving, reasoning and proof, communication, connections, and representation, it was found that significant differences occurred among the quartiles of planning time in all five NCTM areas. Those who planned in the top quartile of time used significantly more problem solving, reasoning and proof, and communication strategies than those in any of the lower quartiles. Those who planned in the top quartile of time used significantly more connection strategies than those in the lower two quartiles. Even when looking at the lower quartiles where planning time was less frequent, there was still a significant difference in the use of reasoning and proof strategies. Therefore, it can be concluded that when it comes to problem solving, reasoning and proof, and communication standards, those who planned in the highest quartile utilized significantly more instructional strategies. It is further concluded that in the reasoning and proof area there is a significant difference even between the two lower quartiles where planning is less frequent. And to that end, even a little more planning impacts the frequency of use of the NCTM standards. Finally, those who planned in the higher two quartiles differed considerably from those in the lower two quartiles with respect to representation strategies. As a consequence, it can be concluded that longer individual planning time not only contributes to a higher mean frequency of NCTM recommended strategies, but it also contributes to a larger variety of strategies as indicated by significant differences in all five process standards.

The finding supports McCutcheon's (1980) study in which she discussed the use of a variety of strategies and found that limited planning time forced teachers to use limited instructional strategies, and it supports Welch's (2000) study in which he found that teams of teachers who had a longer planning time utilized a greater variety of team-teaching strategies than the other team. Use of a variety of strategies is also emphasized in the NCTM's *Principles and* Standards (2000) description of the teaching principle where a focal point of the principle is that teachers employ a variety of pedagogical approaches.

Research Question 2

What differences exist in the perceived frequency of use of the five NCTM process standards by West Virginia Algebra 1 and Applied Math teachers in grades 9-12 in regard to the amount of collaborative planning time?

Not only did the study provide evidence that longer individual planning increases the frequency and variety of NCTM recommended practices, but it also provided evidence for the benefits of collaborative planning. Analysis of the data revealed that statistical differences did occur in the mean frequency of use of NCTM recommended instructional practices among the groups of teachers in different quartiles of collaborative planning time. Significant differences occurred between those who planned the longest and the teachers in the lower two quartiles. Hence, it can be concluded that teachers who use NCTM recommended strategies less frequently are those who plan the least collaboratively and those who use NCTM recommended strategies more frequently are those who plan the most collaboratively. The finding supports those of Warren and Payne (1997) and Kams (2006) who asserted that collaborative planning allows time for the teachers to provide developmentally appropriate instructional activities, one of the NCTM's recommendations and ensure that standards are met. The instructional practices recommended by the NCTM are considered reform practices (Burrill, 1997; Klein, 2003; Willoughby, 1988), and collaborative planning facilitates the utilization of reform strategies (Henning, 2004). Additionally, the finding corroborates those of Decker (2000), Hair et al. (2001), and Trimble (2002) who reported that collaboration results in success with instructional practices and sustained change in practices.

As with individual planning times, the respondents of the survey instrument reported that they did not have enough, if any, collaborative planning time. In fact, 28% of all of the respondents in this study reported zero minutes of collaborative planning time per week. About 17% of those who wrote comments expressed a need to have either a collaborative planning time or more collaborative planning time. Consequently, it can be concluded that many schools do not provide a common planning time and that those who planned the longest did so outside of the school environment. These comments are consistent with the findings of Buechler (1991), Collinson and Cook (2000), Pitler (1997), and Pruitt (1999) who all reported that teachers need more collaborative planning time to share ideas and learn new instructional techniques.

In looking at the specific NCTM strategies as divided into the five process standards of problem solving, reasoning and proof, communication, connections, and representation, it was found that significant differences occurred among the quartiles of planning time in all five NCTM areas. Those who planned in the top two quartiles of time used significantly more communication strategies than those in the lower two quartiles. Similar results were found for the problem solving, reasoning and proof, connection, and representation areas. Mean frequency scores of the respondents in an upper quartile differed significantly from those in a lower quartile. Therefore, it can be concluded that when it comes to problem solving, reasoning and proof, connections, and representation standards, those who planned in the lowest quartile utilized significantly less instructional strategies. Furthermore, those who planned in the higher two quartiles differed considerably from those in the lower two quartiles with respect to communication strategies. For these reasons, it can be concluded that longer collaborative planning time contributes not only to a higher mean frequency of NCTM recommended strategies, but also to a larger variety of strategies as indicated by significant differences in all five process standards.

The finding supports the studies of Holschen (2000), Jitendre et al. (2002), and Quinn (1998) who determined that collaborative planning was critical to developing a variety of student-centered instructional activities that would improve the learning of a majority of students. Additionally, the finding confirms Glatthorn's (1993) recommendation of teacher collaboration as a means to emphasize problem solving and critical thinking and Henning's (2004) report of a collaborative model which resulted in more frequent use of classroom discourse consistent with standards-based instruction.

In addition to the major findings in this study, several ancillary findings were discovered. The ancillary findings involve demographic characteristics of the respondents with respect to planning time and NCTM scores and scores on a traditional set of instructional practices.

Ancillary Question 1

Do the planning habits of the respondents differ based on any of their demographic characteristics?

Age. Significant differences occurred between the quartiles of individual planning times with respect to age. The teachers in the two youngest age groups planned significantly less than teachers in the second oldest group. The differences occurred between the respondents who were in their 20s and 50s and between respondents who were in their 30s and 50s. Since all teachers have the same planning time available during school hours, it can be concluded that older teachers devote more time to planning at home in the evenings and on the weekends than younger teachers. This conclusion goes beyond anything suggested in the literature review. There was no identified study that directly related age to planning time; however, several studies were identified that discussed teaching experience which is a related area to age.

Teaching Experience. Another significant finding in the study was that both individual and collaborative planning times differed significantly by the teaching experience and math teaching experience level of the respondent. Independent t-tests revealed that novice teachers (those with less than 5 years experience as defined by the West Virginia Department of Education) planned significantly less on an individual basis than experienced teachers did. Significance also occurred with respect to math teaching experience. The differences in individual planning quartiles occurred between teachers with the least experience teaching math and those in two groups of more experienced math teachers. So it can be concluded that as the teacher's experience increases so does his or her commitment of time to instructional planning. The differences, with respect to collaborative planning time, occurred between respondents who had taught math for over 30 years and with all groups having less experience. However, the collaborative planning times revealed a reverse trend from what the individual ones did. The teachers with the most experience reported the least amount of collaborative planning time with others. From these results, it can be concluded that as teachers gain experience, their emphasis on collaborative planning diminishes.

This study does not support the findings of Housner and Griffey (1995), Glatthorn (1993), and Lederman and Neiss (2000). In this study, the teachers with the most experience planned longer, whereas, Housner and Griffey reported that more experienced teachers reported less planning time. Additionally, the teachers in the present study collaboratively planned less as they gained experience; however, both Glatthorn (1993) and Lederman and Neiss (2000) recommended that as teachers gain experience, they should spend less time writing detailed lesson plans but instead spend more time collaborating with others.

Highest Degree and Conference Attendance. No significance was found when planning times were compared based on highest degree earned or recent conference attendance. Therefore, it can be concluded that teachers did not individually nor collaboratively plan differently based on degree completed or recent conference attendance.

Ancillary Question 2

Does the mean NCTM score or mean scores for the process standards of the respondents differ based on any of their demographic characteristics?

Age. NCTM scores also appear to differ based on the age of the respondent. The teachers in their 50s scored significantly higher than the teachers in their 30s in the representation area. Furthermore, the teachers in their 50s significantly outscored their counterparts who were in their 40s on the overall mean NCTM scores and problem solving scores. Additionally, the teachers in their 20s scored significantly higher than the teachers in their 50s in the traditional instructional strategies so the teachers in their 50s must have utilized more NCTM recommended strategies than the youngest teachers. In conclusion, the older teachers used more NCTM recommended instructional strategies than the teachers in several of the younger age groups.

This study did not identify older teachers as the most experienced ones nor did it identify experience as important in the use of NCTM skills. To that end, my study fails to substantiate the literature. However, it can be implied that the teachers in their 50s were possibly the most experienced ones in the population. The literature supports differences in use of instructional strategies with respect to experience. Fogarty et al. (1983) observed that experienced teachers utilized twice as many kinds of instructional actions as novice teachers did. In addition, Housner and Griffey (1985) determined that experienced teachers made more decisions about instructional activities than did inexperienced teachers. Fogarty's and Housner's and Griffey's findings may be loosely applied to the findings in this study: instructional actions and decisions may manifest themselves as specific instructional strategies as evidenced by the higher mean scores of the older teachers. More specifically, one of the differences occurred in the problem solving area. Ward, Anhalt, and Vinson (in press) determined that the thinking of preservice elementary teachers as they planned for mathematics instruction was limited in its capacity to encourage higher-level thinking mainly because of lack of classroom discourse. Furthermore, the lack of discourse increased from the initial lesson plans to the final lesson plans. The results of the present study corroborate the findings of Ward et al. that inexperienced (typically younger) teachers may use less problem solving instructional strategies. No study in the literature review specifically identified age as a variable.

Conference Attendance. Conference attendance impacted NCTM scores of the teachers in the present study. The teachers who recently attended conferences scored significantly higher on mean NCTM scores as well as all of the process standard scores except representation. Therefore, it can be concluded that conference attendance clearly impacts the usage of NCTM recommended instructional practices. This finding contradicts those of Smylie (1989) and Zahorik (1987) who reported that teachers often perceive direct experience in the classroom as the most effective sources of learning rather than inservice and conference sessions, university classes, and professional journals.

Ancillary Question 3

How do the respondents score on a set of traditional instructional strategies and does their use of traditional strategies differ based on their planning habits?

Five of the 41 instructional strategies listed in Part 2 of the *Mathematics Instructional Practices Survey* could be categorized as traditional strategies because the NCTM recommends de-emphasizing them. The mean score for the traditional strategies was calculated for each respondent, and an overall mean score of traditional strategies was calculated. One-way ANOVA tests were completed to determine if significant differences occurred between the reported planning times and the mean of the traditional strategies. No significance resulted from the ANOVA tests so the amount of time spent planning individually and collaboratively did not affect the frequency of use of traditional instructional strategies. When independent t-tests were utilized to test demographic variables, group by group, with respect to use of the traditional strategies, only one area of significance emerged. The overall mean of the traditional strategies was similar to that of the NCTM recommended strategies, indicating that the teachers in the study utilized traditional practices with frequencies comparable to the NCTM recommended process standards. The important conclusion, however, is that planning time does increase frequency of use of NCTM recommended strategies, whereas, it does not change use of traditional practices. This finding supports the NCTM's assertion that good lesson planning and lesson implementation are important as methods of improving mathematics learning (Panasuk et al., 2002). The finding also supports the NCTM's definition of a highly qualified teacher as one who knows how to plan, conduct, and assess the effectiveness of mathematics lessons (NCTM, 2005).

Implications

Several implications surface from the completion of the present study. The results of this study reveal that most teachers plan individually instead of collaboratively. Furthermore, it is revealed that teachers must go beyond the planning time provided at school. At the same time, research reveals a clear relationship between the use of NCTM recommended strategies and the amount of collaborative planning time. So there appears to be a disconnect between planning time at school and time necessary to adequately plan for good mathematics instruction. Therefore, although not statistically conclusive, it can be implied from this study that collaborative and individual planning times are not sufficiently organized within the school setting. This study might shed some light on how schools may provide enough individual and collaborative time for planning instruction.

Other implications arise out of the ancillary findings of the study. No identified study in the literature review specifically relates age to either planning time or use of instructional strategies, but several key findings based on age were established. Younger teachers spent less time planning individually for instruction than older teachers. One possible reason, especially for the teachers in their 20s, could be either lack of classroom management skills or lack of experience. Doyle (1986) determined that planning for classroom management is a necessary part of teaching. Bullough (1987) asserted that teachers who have ineffective classroom management skills may avoid planning for risky or fun activities, instead planning for activities that facilitate teacher control of the students. Furthermore, Kagan and Tippins (1992) concluded that the need to control students influenced secondary novice teachers to write extremely scripted lesson plans for lessons that were essentially lectures. Younger teachers are inexperienced teachers by default and novice teachers tend to be younger in age; hence, they may not have adequate classroom management skills. So it may be implied that younger teachers may plan more for classroom management at the expense of effective instructional techniques.

Another possibility for differences in individual planning time based on age is that life cycle position impacts planning habits. Younger teachers in their 20s and 30s are in the midst of family development and have other priorities to attend to rather than instructional planning. One respondent in this study reported that she used to plan at least two hours a night but now has a baby and does not take school work home with her so that she can devote time to her baby. As a result of their multifaceted responsibilities at home and work, teachers in their 30s, who usually have a decade or so of experience, often feel burned out with teaching. The burn out may manifest itself as less time devoted to planning. Once the children have grown and require less time, there may be a renewed enthusiasm for teaching. Teachers now have time to attend conferences, take classes, and devote more time to instructional planning and innovative practices. The teachers in the older age groups of this study reported spending longer times individually planning than the younger teachers. This study shows a trend in individual planning times that maximizes use of strategies so perhaps teachers with limited time may prioritize planning activities to better reflect NCTM recommendations.

On the other hand, the experienced teachers significantly planned less in collaboration with others than the younger teachers. Yet, the older teachers used more NCTM recommended strategies. So if the older teachers could be educated to value collaboration then perhaps their individual planning habits and use of NCTM strategies would positively influence younger teachers.

Differences in mean NCTM scores and process standard scores were also revealed for different age groups. The second oldest age group significantly outscored younger age groups in overall mean NCTM scores, problem solving, and representation scores. The significantly higher scores of the older teachers may be explained by the major findings in this study. It was determined that the older teachers spent more time individually planning than the younger ones. The additional time may have allowed them to research and apply NCTM recommended practices.

Based on the data, it appears that younger teachers are not teaching with NCTM recommended strategies as much as older teachers. This would suggest that they may need to utilize reflection on this. Such reflection would aid them in analyzing the strengths and weaknesses of their delivery of the NCTM recommended process standards.

A final set of implications can be discussed with respect to conference attendance. The teachers in the present study outscored their counterparts who had not recently attended a conference in overall NCTM score and all of the process standard scores with the exception of the representation area. Although not statistically proven, it can be inferred that conference attendance provides exposure to the latest educational research. Consequently, the experience may influence the teachers to take innovative instructional techniques back to their classrooms.

Recommendations for Further Research

This study was undertaken to ascertain if longer individual and collaborative planning times could be associated with a higher mean frequency of use of NCTM recommended practices. Results of a self-report survey indicate that differences in frequency of use do exist based on the length of planning time. It is recommended that a qualitative study on the same topic be completed in order to compare to the findings of this study. Qualitative studies provide "complementary components of the scientific and disciplined inquiry approach" (Gay & Airasian, 2000, p. 10). Qualitative researchers attempt to provide insights into the perspectives of their subjects and carry out comprehensive examinations of their chosen topic over an extended period of time (Gay & Airasian, 2000). A benefit of qualitative research is that the researcher would observe the subjects and report trends present in their behaviors rather than rely on self-report surveys completed by the study participants. The results of a qualitative study coupled with the results from this study may provide a more holistic view of the role of planning with respect to use of NCTM recommended instructional strategies.

It is also recommended that further studies take place that would directly benefit schools. A finding in the study clearly points out that experienced teachers individually plan longer and use NCTM recommended strategies more frequently, hence indicating that mentorship programs would benefit novice teachers. Perhaps another study could examine the role of mentorship programs with respect to improving the effectiveness of instruction. Furthermore, this study provides evidence that planning time does positively affect use of recommended teaching practices. A logical future study would be to determine if staff development programs that train teachers how to plan make a difference in the frequency of use of recommended instructional practices. Moreover, the present study provided evidence that collaborative planning significantly influenced the use of NCTM recommended practices. It would be interesting to investigate whether teachers in schools that provided common planning times utilized more NCTM practices.

Since NCLB is a current educational concern, further research on planning may augment compliance with the policies put forth in the act. For instance, a future study may indicate whether planning time is different between schools who met Adequate Yearly Progress (AYP) goals and those that did not. NCLB also mandates that each state define what a highly qualified teacher is. A possible research topic may be to compare planning times to highly qualified status to determine if differences exist.

Finally, it is recommended that this study be replicated with other groups to corroborate the importance of planning time. It would be interesting to see if planning time is also associated with a higher mean frequency of use of practices recommended by national organizations for other content areas such as English, science, or history. Furthermore, the study may be replicated with other age groups as well, perhaps at the middle school or elementary school levels or by teachers in other geographic areas. The findings of this study provide conflicting evidence about the use of the NCTM process standards based on the age of the respondents so further investigation of the use of the process standards by different age groups may be warranted.

Final Thoughts

In her article, *Breaking the Tyranny of Time: Voices from the Goals 2000 Teacher Forum*, Livingston (1994) asserted that increased planning time for teachers is more important for improving instruction than increased instructional time with students. Livingston's statement is the essence of this dissertation. If students are all held to the same level of achievement of challenging subject matter standards, it must be recognized that they will need varying amounts of time to meet the standards. In turn, teachers must have adequate time to plan for the education of a diverse student population. The National Education Commission on Time and Learning (NECTL) published a report in 1994 called *Prisoners of Time*. One of the NECTL recommendations was that teachers be provided with the time they needed to prepare, plan, collaborate, and professionally grow. Findings from this dissertation provide evidence that longer individual and collaborative planning time do positively impact recommended NCTM instructional practices. Perhaps if teachers can follow the time recommendations of the NECTL and the process standards of the NCTM then students will be better prepared in mathematics to meet the demands of a changing world.

REFERENCES

Adajian, L. (1996). Teachers' professional community and the teaching of mathematics. *Dissertation Abstracts International*, *56*(08), 3038. Abstract retrieved June 13, 2006, from Proquest database.

Adelman, N. (1998). *Trying to beat the clock: Uses of teacher professional time in three countries*. Washington, D.C.: Policy Studies Associates, Inc. (ERIC Document Reproduction Service No. ED420651)

An, S. (2001). A comparative study of mathematics programs in the U.S. and China: The pedagogical content knowledge of middle school mathematics teachers in the U.S. and China. *Dissertation Abstracts International, 61*(11), 4315. (UMI No. 9994202)

Alperin, S. (2001). Teacher attitudes toward increased planning time. *Masters Abstracts International*, 39(01), 15. (UMI No. 1400760)

Artzt, A., & Armour-Thomas, E. (1999). A cognitive model for examining teachers' instructional practice in mathematics: A guide for facilitating teacher reflection [Electronic version]. *Educational Studies in Mathematics*, *40*, 211-235.

Ausubel, D. (1960). The use of advance organizers in the learning and retention of meaningful verbal material. *Journal of Educational Psychology*, *51*, 267-272.

Babbie, E. (1973). *Survey research methods* (2nd ed.). Belmont, CA: Wadsworth, Inc.

Banbury, J. (1998). An analysis of changes in teacher instructional practices under block scheduling in seven suburban high schools. *Dissertation Abstracts International, 59*(03). (UMI No. 9826871)

Barnett, E. (2004). Characteristics and perceived effectiveness of staff development practices in selected high schools in South Dakota [Electronic version]. *Educational Research Quarterly*, *28*(2), 3-18.

Bauwens, J., Hourcade, J., & Friend, M. (1989). Cooperative teacher: A model for general and special education integration. *Remedial and Special Education*, *10*(2), 17-22.

Baylor, A., & Kitsantas, A. (2001). Promoting instructional planning: An experiment. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2001* (pp. 1044-1049). Chesapeake, VA: AACE.

Bell, E., & Bell, R. (1985). Writing and mathematical problem solving: Arguments in favor of synthesis. *School Science and Mathematics*, *85*(3), 210-221.

Bias, K. (n.d.). Constructivism in the classroom. Retrieved June 19, 2006, from http://www.smp.gseis.ucla.edu/Resourcesforyou/LeadingandLearning/v3/vol3no3/699kb.html

Blank, R. (2004). *Data on enacted curriculum study: Summary of findings experimental design study of effectiveness of DEC Professional Development Model on urban middle schools*. Washington, D.C.: Council of Chief State School Officers. (ERIC Document Reproduction Service No. ED484702)

Bluman, A. (2007). *Elementary Statistics: A step by step approach* (4th ed.). New York: McGraw-Hill.

Borasi, R., & Rose, B. (1989). Journal writing and mathematics instruction. *Educational Studies in Mathematics*, *20*, 347-365.

Bottge, B., Heinrichs, M., Mehta, Z., Rueda, E., Hung, Y., & Danneker, J. (2004). Teaching mathematical problem solving to middle school students in math, technology education, and special education classrooms. *Research in Middle level Education Online*, *27*(1), 43-68.

Brandt, M., & Christensen, R. (2002). Improving student social skills through the use of cooperative learning, problem solving, and direct instruction. (ERIC Document Reproduction Service No. ED465929)

Brophy, J. (1999). *Teaching*. Geneva, Switzerland: UNESCO Publications.

Bruner, J. (1960). *The process of education*. Cambridge, MA: Harvard University Press.

Buechler, M. (1991). *Constraints on teachers' classrooms effectiveness: The teacher's perspective*. Bloomington, IL: Education Policy Center. (ERIC Document Reproduction Service No. ED361302)

Bullough, R. (1987). Planning and the first year of teaching [Electronic version]. *Journal of Education for Teaching*, *13*(3), 231-250.

Burns, D., & Reis, S. (1991). Developing a thinking skills component in the gifted education program [Electronic version]. *Roeper Review*, *14*(2), 72-79.

Burrill, G. (1997). The NCTM standards: Eight years later [Electronic version]. *School Science & Mathematics*, *97*(6), 335-339.

Burrill, G. (1998). Changes in your classroom: From the past to the present to the future [Electronic version]. *Journal for Research in Mathematics*, *29*(5), 583-594.

Busatto, S. (2004). What's making the difference in achieving outstanding primary school learning outcomes in numeracy? [Electronic version]. *Australian Primary Mathematics Classroom*, *9*(4), 24-26.

Butty, J. (2000). One case for systemic reform: Differences among four combinations of traditional and reform instructional practices and mathematics performance of 10th and 12th grade African American and Hispanic students. *Dissertation Abstracts International, 61*(03), 882. (UMI No. 9966745)

Canady, R., & Rettig, M. (1995). *Block scheduling: A catalyst for change in high schools*. Princeton, NJ: Eye on Education.

Caron, E., & McLaughlin, M. (2002). Indicators of Beacons of Excellence schools: What do they tell us about collaborative practices? [Electronic version]. *Journal of Educational and Psychological Consultation*, *13*(4), 285-313.

Carpenter, T., & Lehrer, R. (1999). Teaching and learning mathematics with understanding. In E. Fennema & T. Romberg (Eds.), *Mathematics Classrooms That Promote Understanding* (pp. 19-32). Mahweh, NJ: Erlbaum.

Chung, N., & Ro, G. (2004). The effect of problem-solving instruction on children's creativity and self-efficacy in the teaching of the practical arts subject [Electronic version]. *The Journal of Technology Studies*, *30*(2), 116-122.

Clark, C., & Peterson, P. (1986). Teachers' thought processes. In M.C. Wittrock (Ed.), *Third Handbook of Research on Teaching* (pp. 255-296). New York: Macmillan.

Clarke, D. (1994). Ten key principles from research for the professional development of mathematics teachers. In NCTM (Ed.), *Professional Development for Teachers: 1994 Yearbook of the National Council of Teachers of Mathematics* (pp. 37-48). Reston, VA: NCTM.

Collinson, V., & Cook, T. (2000, April). *"I don't have enough time": Teachers' interpretations of time as a key to learning and school change*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Conley, S., Fauske, J., & Pounder, D. (2004). Teacher work group effectiveness [Electronic version]. *Educational Administration Quarterly*, *40*(5), 663-703.

Cooper, S. (1996). Case studies of teacher education students in a field-based and university-based elementary mathematics methods course. *Journal of Teacher Education*, *47*(2), 139-147.

Corbin, G. (1995). A comparison of traditional basal or problem-solving-investigative curriculum and collaborative or non-collaborative planning on third-grade acquisition of multiplication. *Dissertation Abstracts International*, 56(06), 2108. Abstract retrieved June 18, 2006, from Proquest database**.**

Corrick, G. & Ames, J. (2000). Packaged for success. *Book Report, 19*(1), 27-29.

Craig, J., Butler, A., Cairo III, L., Wood, C., Gilchrist, C., Holloway, J., et al. (2005). *A case study of six high-performing schools in Tennessee*. Charleston, WV: Appalachia Educational Laboratory at Edvantia.

Crow, G., & Pounder, D. (2000). Interdisciplinary teacher teams: Context, design, and process [Electronic version]. *Educational Administration Quarterly*, *36*(2), 216-254.

Dallal, G. (2001). *Multiple comparison procedures*. Retrieved July 19, 2007, from Tufts University, Jean Mayer USDA Human Nutrition Research Center on Aging Web site: http://www.tufts.edu/~gdallal/mc.htm

D'Ambrosio, B., Boone, W., & Harkness, S. (2004). Planning district-wide professional development [Electronic version]. *School Science & Mathematics*, *104*(1), 5-15.

Decker, K. (2000). Controlled by the clock: Components and constraints of elementary teachers' scheduled instructional planning time periods. *Dissertation Abstracts International, 61*(02), 502. (UMI No. 9961524)

Doyle, W., & Ponder, G. (1977). The practicality ethic in teacher decision-making. *Interchange*, *8*(3), 1-12.

Doyle W. (1986). Classroom organization and management. In M.C. Wittrock (Ed.), *Third Handbook of Research on Teaching* (pp.392-431). New York: Macmillan.

Dyrli, O. (2007). Curriculum hotspots [Electronic version]. *District Administration, 43*(2), 32-40.

Epstein, M. (1999). Strategies for improving home-school communication about homework for students with disabilities [Electronic version]. *Journal of Special Education*, *33*(3), 166-176.

Erickson, D. (1993, April). *Middle school mathematics teachers' views of mathematics and mathematics education: Their planning and classroom instruction, and student beliefs and achievement*. Paper presented at the annual meeting of the American educational Research Association, Atlanta, GA.

Felner, R., Jackson, A., Kasak, D., Mulhall, P., Brand, S., & Flowers, N. (1997). The impact of school reform for the middle years. *Phi Delta Kappan*, *78*, 528-532, 541-550.

Fennema, E., Sowder, J., & Carpenter, T. (1999). Creating classrooms that promote understanding. In E. Fennema & T. Romberg (Eds.), *Mathematics Classrooms That PromoteUunderstanding* (pp. 185-199). Mahweh, NJ: Erlbaum.

Fogarty, J., Wang, M., & Creek, R. (1983). A descriptive study of experienced and novice teachers' interactive instructional thoughts and actions [Electronic version]. *Journal of Educational Research*, *77*(1), 22-32.

Franca, V., Kerr, M., Reitz, A., & Lambert, D. (1990). Peer tutoring among behaviorally disordered students: Academic and social benefits to tutor and tutee. *Education & Treatment of Children*, *13*, 109-128.

Friend, M., & Cook, L. (1990). Collaboration as a predictor for success in school reform [Electronic version]. *Journal of Educational & Psychological Consultation*, *1*(1), 69-86.

Fullan, M. (1990). Staff-development, innovation, and institutional development. In B. Joyce (Ed.), *Changing School Culture through Staff Development*, (pp. 3-25), Alexandria, VA: Association for Supervision and Curriculum Development.

Gay, L.R., & Airasian, P. (2000). *Educational research*. Upper Saddle River, NJ: Prentice-Hall, Inc.

Giangreco, M. (1997). Key lessons learned about inclusive education: Summary of the 1996 Schonell memorial lecture. *International Journal of Disability*, *44*(3), 193-206.

Glatthorn, A. (1993). Helping teachers do better instructional planning [Electronic version]. *Education Digest*, *59*(2), 16-19.

Glick, J., Ahmed, A., Cave, L., & Chang, H. (1992, March). *Sources used by students teaching in lesson planning*. Paper presented at the NSTA annual conference, Eugene, OR.

Goldstein, L. (2004). Tandem teaching [Electronic version]. *Teacher Magazine*, *15*(5), 48.

Good, T., Reys, B., Grouws, D., & Mulryan, C. (1989). Using work-groups in mathematics instruction [Electronic version]. *Educational Leadership*, *47*(4), 56-62.

Goodlad, J. (1984). *A place called school*. New York: McGraw-Hill.

Groves, S., Mousley, J., & Forgasz, H. (2004). Primary numeracy: A review of Australian research [Electronic version]. *Australian Primary Mathematics Classroom*, *9*(4), 10-13.

Hackman, D. (1995). Ten guidelines for implementing block scheduling. *Educational Leadership*, *53*(3), 24-27.

Hair, D., Kraft, B., & Allen, A. (2001). *National Staff Development Council Project ADVANCE mini-grant: Louisiana Staff Development Council's end of grant report*. Baton Rouge, LA: Louisiana Staff Development Council.

Hargreaves, A. (1993). Teacher development in the postmodern age: Dead certainties, safe simulation, and the boundless self [Electronic version]. *Journal of Education for Teaching*, *19*(2), 95-102.

Hedtke, R., Kahlert, J., & Schwier, V. (2001). Service industry for teachers? Using the Internet to plan lessons [Electronic version]. *European Journal of Education* *36*(2), 189-193.

Henning, C. (2004). Collaborative inquiry groups in secondary mathematics student Teaching. *Dissertation Abstracts International, 65*(02), 443. (UMI No. 3124269)

Hirsch, C., & Coxford, A. (1997). Mathematics for all: Perspectives and promising practices [Electronic version]. *School Science & Mathematics*, *97*(5), 232-241.

Holmes Group Report. (1986). Tomorrow's teachers: A report of the Holmes Group. East Lansing, MI: Holmes Group.

Holschen, C. (2000). The impact of block scheduling on high school mathematics Instruction. *Dissertation Abstracts International, 60*(08), 2782. (UMI No. 9942781)

House, J. (2004). The effects of homework activities and teaching strategies for new mathematics topics on achievement of adolescent studies in Japan: Results from the TIMSS 1999 assessment [Electronic version]. *International Journal of Instructional Media*, *31*(2), 199-210.

Housner, L., & Griffey, D. (1985). Teacher cognition: Differences in planning and interactive decision making between experienced and inexperienced teachers [Electronic version]. *Research Quarterly for Exercise and Sport*, *56*(1), 45-53.

Hughes, S. (2005). Some canaries left behind? Evaluating a state-endorsed lesson plan database and its social construction of who and what counts [Electronic version]. *International Journal of Inclusive Education, 9(2)*, 105-138.

Huppert, J., Lomask, S., & Lazarowitz, R. (2002). Computer simulations in the high school: Students' cognitive stages, science process skills and academic achievement in microbiology [Electronic version]. *International Journal Science Education*, *24*(8), 803-821.

Jackson, A. (1997). *NCTM updating standards documents*. Retrieved July 28, 2003, from American Mathematical Association's Web site: http://www.ams.org/notices/199704/comm-nctm.pdf

Jacobs, G. (2004). A classroom investigation of the growth of metacognitive awareness in kindergarten children through the writing process [Electronic version]. *Early Childhood Education Journal*, *32*(1), 17-23.

Jitendra, A., Edwards, L., Choutka, C., & Treadway, P. (2002). A collaborative approach to planning in the content areas for students with learning disabilities: Accessing the general curriculum [Electronic version]. *Learning Disabilities Research and Practice*, *17*(4), 252-267.

Johnson, B., & Christensen, L. (2000). *Educational research: Quantitative and qualitative approaches*. Boston: Allyn and Bacon, Inc.

Johnson, D., & Johnson, R. (1989). *Cooperation and competition: Theory and Research*. Edina, MN: Interaction Book Company.

Kagan, D., & Tippins, D. (1992). The evolution of functional lesson plans among twelve elementary and secondary student teachers [Electronic version]. *The Elementary School Journal*, *92*(4), 477-489.

Kams, M. (2006). A new kind of middle school [Electronic version]. *Leadership*, *35*(5), 20-23, 37.

Kannapel, P., & Clements, S. (2005). *Inside the black box of high-performing high-poverty school: A report from the Prichard Committee for Academic Excellence*. Lexington, KY: The Prichard Committee for Academic Excellence.

Klein, D. (2003). A brief history of American k-12 mathematics education in the 20thcentury. Retrieved July 28, 2003, from California State University's Web site: **http://www.csun.edu/~vcmth00m/Ahistory.html**

Kramarski, B., Mevarech, Z., & Arami, M. (2002). The effects of metacognitive instruction on solving mathematical authentic tasks [Electronic version]. *Educational Studies in Mathematics*, *49*, 225-250.

Lambert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal*, *27*(1), 29-63.

Lappan, G. (1999a). Countdown to the NCTM standards 2000 [Electronic version]. *Curriculum Administrator*, *35*(4), 18-19.

Lappan, G. (1999b). Revitalizing and refocusing our efforts [Electronic version]. *Mathematics Teaching in the Middle School*, *5*(2), 130-136.

Lederman, N., & Niess, M. (2000). If you fail to plan, are you planning to fail? [Electronic version]. *School Science and Mathematics*, *100*(2), 57-60.

Lenning, O., & Ebbers, L. (1999). The powerful potential of learning communities: Improving education for the future. Washington, DC: Association for the Study of Higher Education. (ERIC Document Reproduction Service No. ED428606)

Lesh, R., Post, T., & Behr, M. (1987). Representations and translations among representations in mathematics learning and problem solving. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics*. Hillsdale, NJ: Erlbaum.

LeTendre, M.J., Wurtzel, J., & Boukris, R. (1999). Title 1 and mathematics instruction: Making the marriage work [Electronic version]. *Teaching Children Mathematics*, 5(5), 270.

Lick, D. (2000). Whole-faculty study groups: Facilitating mentoring for school-wide change [Electronic version]. *Theory into Practice*, *39*(1), 43-49.

Lin, G., & Wang, F. (2002). Using technology to improve instructional planning. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2001* (pp. 2317-2318). Chesapeake, VA: AACE.

Livingston, J. (1994). *Breaking the tyranny of time: Voices from Goals 2000 Teacher Forum*, Washington, DC: Department of Education. (ERIC Document Reproduction Service No. ED414647)

Maccini, P., & Gagnon, J. (2000). Best practices for teaching mathematics to secondary students with special needs [Electronic version]. *Focus on Exceptional Children 32*(5), 1-22.

Martin, W. G., & Berk, D. (2001). The cyclical relationship between research and standards: The case of principles and standards for school mathematics [Electronic version]. *School Science & Mathematics*, *101*(6), 328-339.

Martin, N. (2001). Teacher collaboration: A survey of factors, attitudes, and preferences affecting implementation in mathematics. *Dissertation Abstracts International, 61*(07), 2665. (UMI No. 9977475)

Martinez, J. G. R., & Martinez, N. C. (1998). In defense of mathematics reform and the NCTM's standards [Electronic version]. *Mathematics Teacher*, *91*(9), 746-748.

Marzano, R., Gaddy, B., & Dean, C. (2000). *What works in classroom instruction*. Aurora, CO: Mid-Continent Research for Educational Learning.

Mayer, R. (2003). *Learning and instruction*. New Jersey: Pearson Education, Inc.

McCutcheon, G. (1980). How do elementary school teachers plan? The nature of planning and influences on it. *The Elementary School Journal*, *81*(1), 4-23.

Mercer, C. D., & Harris, C. A. (1993). First invited response: Reforming reforms in mathematics [Electronic version]. *Remedial & Special Education*, *14*(6), 14-19.

Misulis, K. (1997). Content analysis: A useful tool for instructional planning [Electronic version]. *Contemporary Education*, *69*(1), 45-47.

Morrone, A., Harkness, S., D'Ambrosio, B., & Caulfield, R. (2004). Patterns of instructional discourse that promote the perception of mastery goals in a social constructivist mathematics course [Electronic version]. *Educational Studies in Mathematics*, *56*, 19-38.

Murphy, C. (2004). How do children come to use a taught mental calculation strategy? [Electronic version]. *Educational Studies in Mathematics*, *56*, 3-18.

Nahrgang, C., & Peterson, B. (1986). Using writing to learn mathematics. *Mathematics Teacher*, *79*(6), 461-465.

National Board for Professional Teaching Standards. (2000). *About National Board for Professional Teaching Standards.* Retrieved June 7, 2006, from http://www.nbpts.org/about/coreprops.cfm

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: Government Printing Office.

National Commission on Mathematics and Science Teaching. (2000). *The Glenn Commission Report*. Washington, DC: U.S. Government Printing Office.

National Commission on Teaching and America's Future. (1996). *What matters most: Teaching for America's future*. New York.

National Council of Teachers of Mathematics. (1980). *An agenda for action*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (n.d.). *About NCTM*. Retrieved January 27, 2007, from **http://www.nctm.org/about/**

National Council of Teachers of Mathematics. (n.d.). *Mission*. Retrieved July 20, 2003, from **http://www.nctm.org/about/mission.htm**

National Council of Teachers of Mathematics. (n.d.). *NCTM at a glance*. Retrieved July 20, 2003, from **http://www.nctm.org/about/intro.htm**

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics. (1991). *The professional standards for teaching mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2005). Teachers visit NCTM headquarters and launch pilot course [Electronic version]. *News Bulletin*, *42*(3).

National Education Commission on Time and Learning. (1994). *Prisoners of time*. Retrieved January 19, 2008, from http://www.ed.gov/pubs/PrisonersOfTime/index.html

Neber, H., Finsterwald, M., & Urban, N. (2001). Cooperative learning with gifted and high-achieving students: A review and meta-analysis of 12 studies [Electronic version]. *High Ability Studies*, *12*(2), 199-214.

Norusis, M. (2005). *SPSS 14.0 guide to data analysis.* Upper Saddle River, NJ: Prentice Hall Inc.

Ogle, D. (1988/1989). Implementing strategic teaching [Electronic version]. *Educational Leadership*, *46*(4), 47-48.

O'Neal, L., & Cox, D. (2002). Then and now: Small rural schools revisited. Boone, NC: Appalachian State University. (ERIC Document Reproduction Service No. ED464769)

Ornstein, A. (1997). How teachers plan lessons [Electronic version]. *High School Journal*, *80*(4), 227-237.

Oster, E., Graudgenett, N., McGlamery, S., & Top, N. (1999). How to avoid common problems and misunderstandings of the NCTM standards [Electronic version]. *Education*, *120*(2), 397-401.

Panasuk, R., Stone, W., & Todd, J. (2002). Lesson planning strategy for effective mathematics teaching [Electronic version]. *Education*, *122*(4), 808-828.

Pape, S. (1998). Components of a reading comprehension model of mathematical problem-solving and their relation to problem-solving success. *Dissertation Abstracts International, 59*(04), 1069. (UMI No. 9830750)

Pape, S., & Smith, C. (2002). Self-regulating mathematics skills [Electronic version]. *Theory Into Practice*, *41*(2), 93-101.

Peterson, C., & Bond, N. (2004). Online compared to face-to-face teacher preparation for learning standards-based planning skills [Electronic version]. *Journal of Research on Technology in Education*, *36*(4), 345-360.

Peterson, P., Marx, R., & Clark, C. (1978). Teacher planning, teacher behavior, and student achievement. *American Educational Research Journal*, *15*, 417-432.

Picucci, A., Brownson, A., Kahlert, R., & Sobel, A. (2002). *Driven to succeed: High-performing, high-poverty, turnaround middle schools. Volume 1: Cross-case analysis of high-performing, high-poverty, turnaround middle schools.* Washington, DC: US Department of Education.

Pitler, H. (1997). Elementary teacher planning time: Current practices and recommendations. *Dissertation Abstracts International, 58*(04), 1168. (UMI No. 9730259)

Protheroe, N. (2004). NCLB dismisses research vital to effective teaching [Electronic version]. *Education Digest*, *69*(8), 27-30.

Pruitt, J. (1999). An analysis of instructional strategies and teaching behaviors associated with teachers of mathematics in high schools operating a four-period block schedule. *Dissertation Abstracts International, 60*(04),1056. (UMI No. 9825821)

Quinn, K. (1998). The effects of intensified scheduling on instructional methodologies. *Dissertation Abstracts International, 58*(09), 3467. (UMI No. 9808219)

Rettig, M., McCullough, L., Santos, K., & Watson, C. (2003). A blueprint for increasing student achievement [Electronic version]. *Educational Leadership*, *61*(3), 71-76.

Reyes, B., & Robinson, E. (1999). Mathematics curricula based on rigorous national standards [Electronic version]. *Phi Delta Kappan, 80*(6), 454-456.

Richards, J. (1991). Mathematical discussions. In E. von Glasersfeld (Ed.), *Radical constructivism in mathematics education* (pp. 13-51). Netherlands: Kluwer Academic Publishers.

Rizor, D. (2000). Wyoming teacher survey of instruction in elementary mathematics. *Dissertation Abstracts International*, 61(06), 2191. (UMI No. 9973572)

Robbins, J. (1993). *Testimony before National Education Commission on Time and Learning*. Ypsilanti, MI: National Education Commission on Time and Learning. (ERIC Document Reproduction Service No. ED357464).

Roitman, J. (1998). A mathematician looks at national standards [Electronic version]. *Teachers College Record*, *100*(1), 22-44.

Romberg, T. A. (1993). NCTM's standards: A rallying flag for mathematics teachers [Electronic version]. *Educational Leadership*, *50*(5), 36-41.

Rose, R. (2001). Primary school teacher perceptions of the conditions required to include pupils with special educational needs [Electronic version]. *Educational Review*, *53*(2), 147-156.

Russ, W.L. (1992). IRA, NCATE boards to meet to discuss national standards [Electronic version]. *Reading Today*, *10*(2), 1-2.

Rutherford, B., & Broughton, M. (2000). *Teaching and learning in the middle schools: Lessons from an urban community*. Austin, TX: Southwest Educational Development Lab. (ERIC Document Reproduction Service No. ED449262)

Salvaterra, M., & Adams, D. (1995). Departing from tradition: Two schools' stories. *Educational Leadership*, *53*(3), 32-33.

Sardo-Brown, D. (1990). Experienced teachers' planning practices: A US survey [Electronic version]. *Journal of Education for Teaching*, *16*(1), 57-71.

SAS/STAT User's Guide, Version 8, SAS Institute 1999.

Schroeder, K. (1991). Math standards [Electronic version]. *Education Digest*, *56*(9), 65.

Serafino, K., & Cicchelli, T. (2003). Cognitive theories, prior knowledge, and anchored instruction on mathematical problem solving and transfer [Electronic version]. *Education and Urban Society*, *36*(1), 79-92.

Sherin, M., Mendez, E., & Louis, D. (2004). A discipline apart: The challenge of 'fostering a community of learners' in a mathematics classroom [Electronic version]. *Journal of Curriculum Studies*, *36*(2), 207-232.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-22.

Silver, E. (1998). Improving mathematics in middle school: Lessons from TIMSS and related research. Office of Educational research and Improvement: Washington, D.C. (ERIC Document Reproduction Service No. ED417956)

Simon, M. (1992, April). *Learning mathematics and learning to teach: Learning cycles in mathematics teacher education*. Paper presented at the Annual Meeting of the American Educational research Association, San Francisco, CA.

Slavin, R. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin*, *94,* 429-445.

Small, R., Sutton, S., Miwa, M., Urfels, C., & Eisenberg, M. (1998). Information seeking for instructional planning: An exploratory study [Electronic version]. *Journal of Research on Computing*, *31*(2), 204-219.

Smith, C. (1999). Underprepared college students' approaches to learning mathematics while enrolled in a strategy-embedded developmental mathematics course and while subsequently enrolled in a college-level mathematics course that did not purposefully emphasize the use of mathematics-specific learning strategies. *Dissertation Abstracts International, 59*(08), 2896. (UMI No. 9900916)

Smith, K., & Geller, C. (2004). Essential principles of effective mathematics instruction: Methods to reach all students [Electronic version]. *Preventing School Failure*, *48*(4), 22-29.

Smith, M. L., & Glass, G. V. (1987). *Research and evaluation in education and the social sciences*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Sparks, D. (1994). *Time for learning: A view from the national level*. NCREL's Policy Brief [Electronic version]. Retrieved July,2, 2006, from http://www.ncrel.org/sdrs/areas/issues/envrnmnt/go/94-4sprk.htm

Smylie, M. (1989). Teachers' views of the effectiveness of sources of learning to teach. *The Elementary School Journal*, *89*(5), 543-558.

Souviney, R. (1989). *Learning to teach mathematics*. New York: Merrill/Macmillan.

St. Clair, J. (1998). High school algebra teachers' beliefs and practices toward using reading, writing, and dialogue as instructional strategies. *Dissertation Abstracts International, 58*(11), 4216. (UMI No. 9815623)

Stigler, J., & Hiebert, J. (2004). Improving mathematics teaching [Electronic version]. *Educational Leadership*, *61*(5), 12-17.

Stonewater, J. (2002). The mathematics writer's checklist: The development of a preliminary assessment tool for writing in mathematics [Electronic version]. *School Science & Mathematics*, *102*(7), 324-334.

Taylor, L. M. (2004). The power of time and teamwork: The impact of instructional planning time and collaboration on the effectiveness of lesson planning by classroom teachers. *Dissertation Abstracts International, 65*(05),1743. (UMI No. 3134696)

Taylor, P. (2001). Collegial interactions among Missouri high school mathematics teachers: Examining the context of reform. *Dissertation Abstracts International, 62*(05), 1764. (UMI No. 3013034)

Trimble, S. (2002). Common elements of high-performing, high-poverty middle schools. *Middle School Journal*, *33*(4), 7-16.

U.S. Department of Education. (1999). *Hope for urban education: A study of nine high-performing, high-poverty, urban elementary schools.* Washington, DC: Author.

U.S. Department of Education. (2002). *No child left behind: A desktop reference*. Washington, DC: Author.

Viale, J. (2005). Teacher perceptions of the effects of instructional planning time on classroom implementation of academic standards. *Masters Abstracts International*, *43*(02), 365. (UMI No. 1423078)

Walberg, H., & Paik, S. (2004). Effective general practices. In G. Cawelti (Ed.), *Handbook of research on improving student achievement* (3rd edition, pp. 25-38). Arlington, VA: Educational Research Service.

Walston, D. (2001). Improving the quality of teaching using collaborative professional development: The teachers teaching with technology (T^3) institutes. *Mathematics Education Dialogues*, 929-1466.

Ward, R., Anhalt, C., & Vinson, K. (in press). Mathematical representations and pedagogical content knowledge: An investigation of prospective teachers' development [Electronic version]. *Focus on Learning Problems in Mathematics.*

Warger, C., & Rutherford, R. (1993). Co-teaching to improve social skills [Electronic version]. *Preventing School Failure*, *37*(4), 21-26.

Warren, L., & Payne, B. (1997). Impact of middle grades' organization on teacher efficacy and environmental perceptions [Electronic version]. *Journal of Educational Research*, *90*(5), 301-308.

Weiss, I., & Pasley, J. (2004). What is high quality instruction? [Electronic version]. *Educational Leadership*, *61*(5), 24-28.

Welch, M. (1998). Collaboration: Staying on the bandwagon [Electronic version]. *Journal of Teacher Education*, *49*(1), 26-37.

Welch, M. (2000). Descriptive analysis of team teaching in two elementary classrooms: A formative experimental approach [Electronic version]. *Remedial & Special Education*, *21*(6), 366-376.

Wendel, R. (1990, April). *A longitudinal study of beginning secondary teachers' decision-making from planning through instruction*. Paper presented at the American Educational Research Association, Boston, MA.

West, J. (1990). Educational collaboration in the restructuring of schools. *Journal of Educational & Psychological Consultation, 1*(1), 23-40.

West Virginia Board of Education Policy 2520.2. (2003). *Mathematics Content Standards and Objectives for West Virginia Schools.*

West Virginia Board of Education Policy 2510. (2006). *Assuring the Quality of Education: Regulations for Education Programs.*

Wickstrom, R. (1995). Sustaining educational reform. *Education Canada*, *35*(4), 4-8.

Willoughby, S. S. (1988). Liberating standards for Mathematics from NCTM [Electronic version]. *Educational Leadership*, *46*(2), 82.

Winograd, K. (1990). Writing, solving, and sharing original math story problems: Case studies of fifth grade children's cognitive behavior. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago.

Wolf, M. (2003). Teacher time: A study of time and tasks required to complete job related work. *Dissertation Abstracts International, 63*(08), 2767. (UMI No. 3062132)

Wood, F., & Thompson, S. (1980). Guidelines for better staff development [Electronic version]. *Educational Leadership*, *37*, 374-378.

Yackel, E., Cobb, P., & Wood, T. (1991). Small-group interactions as a source of learning opportunities in second-grade mathematics. *Journal for Research in Mathematics Education*, *22*(5), 390-408.

Yamaguchi, R. (2003, April). *Children's learning groups: A study of emergent leadership, dominance, and group effectiveness*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Yinger, R. (1980). A study of teacher planning [Electronic version]. *The Elementary School Journal*, *80*(3), 107-127.

Ysseldyke, J., Betts, J., Thill, T., & Hannigan, E. (2004). Use of an instructional management system to improve mathematics skills for students in Title 1 programs [Electronic version]. *Preventing School Failure*, *48*(4), 10-14.

Zahorik, J. (1970). The effects of planning on teaching. *Elementary School Journal*, *71*, 143-151.

Zahorik, J. (1975). Teachers' planning models [Electronic version]. *Educational Leadership*, *33*, 134-139.

Zahorik, J. (1987). Teachers' collegial interactions: An exploratory study [Electronic version]. *Elementary School Journal*, *42*, 545-551.

APPENDICES

Appendix A: The Mathematics Instructional Practices Survey

Appendix B: Instructional Practices Recognized in the Literature

Appendix C: Panel of Experts

Appendix D: Content Validity Questions for Panel of Experts

Appendix E: Cover Letter First Survey Mailing

Appendix F: Cover Letter Second Survey Mailing

Appendix G: Statistical Test Results

APPENDIX A: THE MATHEMATICS INSTRUCTIONAL PRACTICES SURVEY

Instructional Practices Survey

Please read carefully!
In an effort to better understand the instructional practices of West Virginia high school Algebra 1 and Applied Math teachers, you are asked to complete this survey.

The survey has three sections.

Part 1- Planning Time Information
Part 2- Instructional Practices
Part 3- General Information

Please answer directly on the survey by checking the appropriate box, circling the appropriate number, or writing your response in the space provided.

Please note that the information used in this survey will be confidential, therefore, your name or the name of your school will not be used or reported for any purpose.

Thank you for completing the survey!

Part 1
Planning Time Information

Definitions:

Individual planning time- time spent preparing lessons and materials prior to instructional delivery or time spent reflecting on effectiveness of instruction (this does not include time for grading, parent conferences, making copies, etc)

Collaborative planning time- a common planning time that two or more teachers share to plan lessons prior to instruction or time spent reflecting on effectiveness of instruction

Answer the following questions as completely as possible.

1. How long is your official planning period per day in minutes? ___________________
2. How many math teachers work in your school? ___________________
3. How do you view the importance of collaboration with others in planning instructional activities? (circle one)

not important   somewhat important   important   very important

4. Select the option below that applies to you and answer the questions with the option.

☐ I teach in a **traditional** or **4x4 block**

Based on the above definition of individual planning time, on average, how much time per week in minutes do you spend planning at school or at home?

____

Based on the above definition of collaborative planning time, on average, how much time per week do you spend in collaboration with other math teachers in the school setting or elsewhere in minutes?

____

☐ I teach in an **alternating block**

Based on the above definition of individual planning time, on average, how much time per two weeks in minutes do you spend planning at school or at home?

____

Based on the above definition of collaborative planning time, on average, how much time per two weeks do you spend in collaboration with other math teachers in the school setting or elsewhere in minutes?

____

Part 2
Instructional Practices

In your mathematics class/es, how often do you complete the following instructional activities? Circle one per line. If you teach in a **traditional** or **4x4 block** schedule then refer to the definitions in column 1. If you teach in an **alternating block** schedule, refer to the definitions in column 2.

TRADITIONAL OR 4X4 BLOCK
Never- not used at all
Rarely- used 1 or 2 times per semester
Occasionally- used 1 or 2 times per month
Frequently- used 1 or 2 times per week
Daily- used each day of class

ALTERNATING BLOCK
Never- not used at all
Rarely- used 1 or 2 times per semester
Occasionally- used 1 or 2 times per 2 months
Frequently- used 1 or 2 times per 2 weeks
Daily- used each day of class

I have my students	Never	Rarely	Occasionally	Frequently	Daily
1. use problem solving such as drawing a picture, working backwards, looking for patterns, solving a simpler problem	1	2	3	4	5
2. explain solution to a problem in words in either written or verbal form	1	2	3	4	5
3. memorize mathematical facts and algorithms	1	2	3	4	5
4. use manipulatives to transfer mathematical ideas to words	1	2	3	4	5
5. relate a math concept to another subject area	1	2	3	4	5
6. work in groups to find solutions	1	2	3	4	5
7. write word problems for other students to solve	1	2	3	4	5
8. represent words as mathematical symbols	1	2	3	4	5
9. relate a math concept to real life	1	2	3	4	5
10. answer higher level thinking questions	1	2	3	4	5
11. complete pencil/paper drills	1	2	3	4	5
12. use a calculator, computer, etc. (technology) to discover a mathematical concept or pattern	1	2	3	4	5
13. use a journal to express mathematical ideas	1	2	3	4	5
14. use multiple modes of representation to illustrate a mathematical concept	1	2	3	4	5
15. relate a new math concept to a previously learned math concept	1	2	3	4	5
16. formulate more elaborate answer to posed questions by using wait time in my oral questioning	1	2	3	4	5

	Never	Rarely	Occasionally	Frequently	Daily
17. go to the board and work problems	1	2	3	4	5
18. use manipulatives to discover a mathematical concept or pattern	1	2	3	4	5
19. use mathematical terminology correctly in explanation of solution	1	2	3	4	5
20. complete a hands-on activity	1	2	3	4	5
21. relate a math concept to personal life	1	2	3	4	5
22. use technology to make or test conjectures	1	2	3	4	5
23. complete terminology quizzes	1	2	3	4	5
24. focus on self-regulation skills such as persistence or motivation	1	2	3	4	5
25. represent an aspect of real life as a mathematical model	1	2	3	4	5
26. relate a math concept to the workplace	1	2	3	4	5
27. estimate the reasonableness of an answer	1	2	3	4	5
28. take notes based on my lectures	1	2	3	4	5
29. use inquiry/investigation to discover a mathematical concept	1	2	3	4	5
30. organize presentations on mathematical concepts	1	2	3	4	5
31. complete a project that takes several days	1	2	3	4	5
32. complete mental calculations	1	2	3	4	5
33. respond to advanced organizers or anticipatory sets to activate previous knowledge	1	2	3	4	5
34. complete writing assignments	1	2	3	4	5
35. use supplementary sources such as newspapers, magazines, Internet, etc.	1	2	3	4	5
36. use class/group discussion to justify a solution	1	2	3	4	5
37. analyze their mistakes in writing	1	2	3	4	5
38. make choices as to project	1	2	3	4	5
39. use graphs, charts, diagrams, webs, etc. to explain mathematical concept	1	2	3	4	5
40. complete mathematics portfolios	1	2	3	4	5
41. make choices about solution strategies	1	2	3	4	5

Please provide any additional comments regarding your planning time or use of instructional strategies in the space below.

Part 3
General Information

Mark the appropriate box:

1. Sex ☐ male ☐ female

2. Age ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+

3. Years as a teacher? ☐ 0-4 ☐ 5-9 ☐ 10-14 ☐ 15-19
☐ 20-24 ☐ 25-29 ☐ 30-34 ☐ 35+

4. Years as a high school mathematics teacher? ☐ 0-4 ☐ 5-9 ☐ 10-14 ☐ 15-19
☐ 20-24 ☐ 25-29 ☐ 30-34 ☐ 35+

5. Are you certified in mathematics 5-12, 7-12, or 9-12? ☐ Yes ☐ No

6. If you answered no in question 5, are you certified to teach through Algebra 1? ☐ Yes ☐ No ☐ N/A

7. In what grade do you teach Algebra 1 or Applied Math? ___________________

8. Which best describes the frequency you teach your classes?
☐ every day ☐ every other day ☐ other, please describe
____

9. What is the highest academic degree you hold?
☐ bachelor's ☐ master's ☐ education specialist ☐ doctorate

10. Do you have a national board certification? ☐ Yes ☐ No

11. Check the professional math organizations in which you hold membership.

☐ The Mathematical Association of America (MAA)
☐ The American Mathematical Society (AMS)
☐ The National Council of Teachers of Mathematics (NCTM)
☐ The West Virginia Council of Teachers of Mathematics (WVCTM)
☐ The Association for Women in Mathematics (AWM)
☐ The National Association of Mathematicians (NAM)
☐ Other (please specify) ____

12. Have you attended a professional conference in the last 2 years? ☐ Yes ☐ No

Thanks!

APPENDIX B: INSTRUCTIONAL PRACTICES RECOGNIZED IN THE LITERATURE

Strategy	Author
Problem Solving Practices	
monitor and reflect on the process of mathematical problem solving	Carpenter & Lehrer, Jacobs, Kramarski et al.
use a calculator, computer, etc. (technology) to discover a mathematical concept or pattern	D'Ambrosio, et al., Hirsch & Coxford, Maccini & Gagnon, Ysseldyke et al.
focus on self-regulation skills such as persistence or motivation or learning strategies	Good et al., House, Jacobs, Pape & Smith, Yamaguchi, Ysseldyke et al.
use inquiry/investigation to discover a mathematical concept	D'Ambrosio et al., House
complete a project that takes several days	D'Ambrosio et al.
teach problem solving approaches such as drawing a picture, working backwards, etc.	Brandt & Christensen
Reasoning and Proof Practices	
recognize reasoning and proof as fundamental aspects of mathematics	Groves et al.
select and use various types of reasoning and methods of proof	Artzt & Armour-Thomas, Fennema et al.
answer higher level thinking questions	Artzt & Armour-Thomas, Good et al., Morrone et al., Neber et al., Ward et al.
formulate more elaborate answer to posed questions by using wait time in my oral questioning	Artzt & Armour-Thomas, Busatto
use technology to make or test conjectures	D'Ambrosio et al., Huppert et al., Ward et al.
complete mental calculations	Murphy
analyze their mistakes in writing	Pape & Smith

explain solution to a problem in words in either written or verbal form	Artzt & Armour-Thomas, Busatto, Carpenter & Lehrer, Fennema et al., Pape & Smith, Sherin et al., St. Clair

Communication Practices

work in groups to find solutions	Good et al., Hirsch & Coxford, Houston & Lazenbatt, Lambert, Maccini & Gagnon, Morrone et al., Neber et al., Yamaguchi
write word problems for other students to solve	D'Ambrosio et al., Winograd
use a journal to express mathematical ideas	Nahrgang & Peterson, Peyton, St. Clair
organize presentations on mathematical concepts	Carpenter & Lehrer
complete writing assignments	Bell & Bell, Busatto, Fennema et al., Jacobs, Maccini & Gagnon, Pape & Smith, St. Clair, Stonewater, Ward et al.
use class/group discussion to justify a solution	Artzt & Armour-Thomas, D'Ambrosio et al., Howe, Morrone et al., Pape & Smith, Richards, St. Clair, Ward et al.

Connection Practices

understand how mathematical ideas interconnect and build on one another to produce a coherent whole	Carpenter & Lehrer, Groves et al., Morrone et al., Stigler & Hiebert
relate a math concept to another subject area	House
relate a math concept to real life	Groves et al., House, Macinni & Gagnon, Ward et al., Weiss & Pasley,
relate a math concept to a previously learned math concept	Carpenter & Lehrer, Groves et al.
relate a math concept to the workplace	Bottge et al.
complete an advanced organizer or	Artzt & Armour-Thomas, Ausubel,

“sponge” to activate previous knowledge	Busatto, Mayer
embed problem solving in real world contexts	Bottge et al., Maccini & Gagnon, Serafino & Cicchelli

Representation Practices

use manipulatives to transfer mathematical ideas to words	Carpenter & Lehrer, Maccini & Gagnon, Ward et al.
use multiple modes of representation to illustrate a mathematical concept	Artzt & Armour-Thomas, Lesh et al., Ward et al.
represent an aspect of real life as a mathematical model	Hirsch & Coxford
complete a hands-on activity	D’Ambrosio et al.
use charts, diagrams, webs, etc. to explain mathematical concept	Carpenter & Lehrer

Traditional Practices

memorize mathematical facts and algorithms	Klein, NCTM, Romberg
complete pencil/paper drills	Klein, NCTM
take notes based on lectures	Klein, NCTM

APPENDIX C: PANEL OF EXPERTS

The following individuals served as a panel of experts to establish content validity for the *Mathematics Instructional Practices Survey*.

Peggy S. Baldwin
Curriculum Specialist
Wyoming County Schools
Pineville, West Virginia

Beth Cipoletti, Ed.D.
West Virginia Department of Education
Coordinator in Office of Assessment and Accountability
Charleston, West Virginia

Deborah D. Clark, Ed.S.
Coalfield Rural Systemic Initiative - Edvantia, Inc.
WV Codirector/Math Content Specialist
Hinton, West Virginia

Murrel Brewer Hoover, NBCT
STEM Center Mathematics Specialist
June Harless Center for Rural Educational Research and Development
Marshall University
Huntington, West Virginia

Lou Maynus, NBCT
West Virginia Department of Education
Coordinator, Mathematics & Math Science Partnership
Charleston, West Virginia

Jane Sims
West Virginia department of Education
Coordinator, Mathematics Assessment
Charleston, West Virginia

Olivia Teel
(retired) Mathematics Curriculum Specialist K-12
Kanawha County Schools
Charleston, West Virginia

APPENDIX D: CONTENT VALIDITY QUESTIONS FOR PANEL OF EXPERTS

1. Are the questions written as to be uniformly understood or interpreted by high school math teachers?
2. Are the questions too vague?
3. Are the questions biased?
4. Are the questions too demanding?
5. Do any of the questions embody a double question?
6. Are the answers mutually exclusive?
7. Do the questions assume too much knowledge on the respondent's part?
8. Was the scale for Part 2 clear?
9. Was the survey organized well?
10. How long did it take you to complete the survey?
11. Recommendations for improvement.

(adapted from Smith & Glass, 1987, p. 248)

APPENDIX E: COVER LETTER FIRST SURVEY MAILING

April 25, 2007

Dear Mathematics Teacher,

My name is Kerri Lookabill, and I am an Assistant Professor of Mathematics at Mountain State University. I am also a doctoral candidate in the Marshall University Curriculum and Instruction program. For my dissertation, I am conducting a study of West Virginia high school mathematics teachers' amount of planning and their utilization of various instructional strategies.

You are among those invited to participate in this study. The population of this study includes all of the mathematics teachers in grades 9-12 that teach Algebra 1 and/or Applied Math throughout West Virginia, approximately 811 teachers. I would appreciate your time and consideration in completing and returning the enclosed survey. The survey will take approximately 15 minutes to complete. Your participation is voluntary as you are not required to take part and you may withdraw from the study at any time, both of these without any penalty. Your participation will greatly strengthen my study. Confidentiality will be maintained throughout the study. Identification of return envelopes will be utilized in order to help me track responses; the surveys will not be identified. Data will be reported in the aggregate form only. This study has been reviewed and approved by the Institutional Review Board of Marshall University. For any questions or concerns about your rights as a research participant, contact Dr. Stephen Cooper, IRB #2 Chair at 304-696-4303.

While there is no direct benefit to you at this time, possible benefits from this research include reallocation of planning time to ensure that instructional strategies positively influence student learning. In addition, this study may add to the knowledge base for teacher education or professional development programs. A summary of study results will be made available to those who participate.

Please return the completed survey by May 11, 2007. For your convenience, I have enclosed a stamped, self-addressed envelope for you to return the survey. If you have any questions, feel free to contact me at 304-929-1466 or by email at klookabill@mountainstate.edu. You may also contact my dissertation chair, Dr. Cal Meyer, Marshall University Graduate College, at 304-746-1936, or by email at meyer@marshall.edu.

Thank you in advance for your cooperation and participation in this study!

Sincerely,

Kerri Lookabill

APPENDIX F: COVER LETTER SECOND SURVEY MAILING

May 11, 2007

Dear Mathematics Teacher,

My records indicate that you have not returned the survey that I mailed to you on mid-April, 2007. Perhaps you have misplaced the survey.

To remind you of the purpose of the study, I am conducting a study of West Virginia high school mathematics teachers' amount of planning and their utilization of various instructional strategies. The population of this study includes all of the mathematics teachers in grades 9-12 that teach Algebra 1 and/or Applied Math throughout West Virginia, approximately 811 teachers. I would appreciate your time and consideration in completing and returning the enclosed survey. The survey will take approximately 15 minutes to complete. Your participation is voluntary as you are not required to take part, and you may withdraw from the study at any time, both of these without penalty. Your participation will greatly strengthen my study. Confidentiality will be maintained throughout the study. Identification of return envelopes will be utilized in order to help me track responses; the surveys will not be identified. Data will be reported in the aggregate form only. This study has been reviewed and approved by the Institutional Review Board of Marshall University. For any questions or concerns about your rights as a research participant, contact Dr. Stephen Cooper, IRB #2 Chair at 304-696-4303.

While there is no direct benefit to you at this time, possible benefits from this research include reallocation of planning time to ensure that instructional strategies positively influence student learning. In addition, this study may add to the knowledge base for teacher education or professional development programs. A summary of study results will be made available to those who participate.

Please return the completed survey by May 25, 2007. For your convenience, I have enclosed a stamped, self-addressed envelope for you to return the survey. If you have any questions, feel free to contact me at 304-929-1466 or by email at klookabill@mountainstate.edu. You may also contact my dissertation chair, Dr. Cal Meyer, Marshall University Graduate College, at 304-746-1936, or by email at meyer@marshall.edu.

Thank you in advance for your cooperation and participation in this study!

Sincerely,

Kerri Lookabill

APPENDIX G: STATISTICAL TEST RESULTS

Table 5

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Instructional Strategies based on Quartiles of Individual Planning Time

Quartiles for Individual Planning Times (I)	Quartiles for Individual Planning Times (J)	Mean Difference (I – J)	Significance
1st Quartile	2nd Quartile	-.13528	.076
	3rd Quartile	-.22911	.005*
	4th Quartile	-.49593	.000*
2nd Quartile	1st Quartile	.13528	.076
	3rd Quartile	-.09383	.230
	4th Quartile	-.36065	.000*
3rd Quartile	1st Quartile	.22911	.005*
	2nd Quartile	.09383	.230
	4th Quartile	-.26682	.005*
4th Quartile	1st Quartile	.49593	.000*
	2nd Quartile	.36065	.000*
	3rd Quartile	.26682	.005*

* denotes significance at $p < .05$

Table 7

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Process Standards based on Quartiles of Individual Planning Time

Dependent Variable	Quartiles for Individual Planning Times (I)	Quartiles for Individual Planning Times (J)	Mean Difference (I – J)	Significance
Problem Solving	1st Quartile	2nd Quartile	-.16147	.054
		3rd Quartile	-.24892	.006*
		4th Quartile	-.53539	.000*
	2nd Quartile	1st Quartile	.16147	.054
		3rd Quartile	-.08745	.309
		4th Quartile	-.37392	.000*
	3rd Quartile	1st Quartile	.24892	.006*
		2nd Quartile	.08745	.309
		4th Quartile	-.28647	.007*
	4th Quartile	1st Quartile	.53539	.000*
		2nd Quartile	.37392	.000*
		3rd Quartile	.28647	.007*
Reasoning & Proof	1st Quartile	2nd Quartile	-.19907	.021
		3rd Quartile	-.20695	.024
		4th Quartile	-.51279	.000*
	2nd Quartile	1st Quartile	.19907	.021
		3rd Quartile	-.00787	.929
		4th Quartile	-.31372	.002*
	3rd Quartile	1st Quartile	.20695	.024
		2nd Quartile	.00787	.929
		4th Quartile	-.30584	.005*
	4th Quartile	1st Quartile	.51279	.000*
		2nd Quartile	.31372	.002*
		3rd Quartile	.30584	.005*

Communication	1st Quartile	2nd Quartile	-.17763	.062
		3rd Quartile	-.26905	.008*
		4th Quartile	-.61833	.000*
	2nd Quartile	1st Quartile	.17763	.062
		3rd Quartile	-.09142	.350
		4th Quartile	-.44070	.000*
	3rd Quartile	1st Quartile	.26905	.008
		2nd Quartile	.09142	.350
		4th Quartile	-.34928	.004*
	4th Quartile	1st Quartile	.61833	.000*
		2nd Quartile	.44070	.000*
		3rd Quartile	.34928	.004*
Connections	1st Quartile	2nd Quartile	-.04150	.654
		3rd Quartile	-.10668	.280
		4th Quartile	-.31758	.006*
	2nd Quartile	1st Quartile	.04150	.654
		3rd Quartile	-.06518	.493
		4th Quartile	-.27609	.013*
	3rd Quartile	1st Quartile	.10668	.280
		2nd Quartile	.06518	.493
		4th Quartile	-.21091	.070
	4th Quartile	1st Quartile	.31758	.006*
		2nd Quartile	.27609	.013*
		3rd Quartile	.21091	.070
Representation	1st Quartile	2nd Quartile	-.09674	.309
		3rd Quartile	-.31395	.002*
		4th Quartile	-.49556	.000*
	2nd Quartile	1st Quartile	.09674	.309
		3rd Quartile	-.21721	.027*
		4th Quartile	-.39882	.001*
	3rd Quartile	1st Quartile	.31395	.002*
		2nd Quartile	.21721	.027*
		4th Quartile	-.18160	.128
	4th Quartile	1st Quartile	.49556	.000*
		2nd Quartile	.39882	.001*
		3rd Quartile	.18160	.128

* denotes significance at $p < .05$

Table 9

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Instructional Strategies based on Quartiles of Collaborative Planning Time

Quartiles for CollaborativePlanning Times (I)	Quartiles for CollaborativePlanning Times (J)	Mean Difference (I – J)	Significance
1st Quartile	2nd Quartile	-.04948	.520
	3rd Quartile	-.20244	.008*
	4th Quartile	-.40150	.009*
2nd Quartile	1st Quartile	.04948	.520
	3rd Quartile	-.15296	.085
	4th Quartile	-.35202	.027*
3rd Quartile	1st Quartile	.20244	.008*
	2nd Quartile	.15296	.085
	4th Quartile	-.19905	.209
4th Quartile	1st Quartile	.40150	.009*
	2nd Quartile	.35202	.027*
	3rd Quartile	.19905	.209

* denotes significance at $p < .05$

Table 11

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Mean Frequency of NCTM Process Standards based on Quartiles of Collaborative Planning Time

Dependent Variable	Quartiles for Collaborative Planning Times (I)	Quartiles for Collaborative Planning Times (J)	Mean Difference (I – J)	Significance
Problem Solving	1st Quartile	2nd Quartile	-.12679	.136
		3rd Quartile	-.20316	.016*
		4th Quartile	-.38896	.021*
	2nd Quartile	1st Quartile	.12679	.136
		3rd Quartile	-.07637	.434
		4th Quartile	-.26217	.135
	3rd Quartile	1st Quartile	.20316	.016*
		2nd Quartile	.07637	.434
		4th Quartile	-.18580	.287
	4th Quartile	1st Quartile	.38896	.021*
		2nd Quartile	.26217	.135
		3rd Quartile	.18580	.287
Reasoning & Proof	1st Quartile	2nd Quartile	-.09598	.266
		3rd Quartile	-.14654	.086
		4th Quartile	-.44351	.010*
	2nd Quartile	1st Quartile	.09598	.266
		3rd Quartile	-.05056	.611
		4th Quartile	-.34753	.052
	3rd Quartile	1st Quartile	.14654	.086
		2nd Quartile	.05056	.611
		4th Quartile	-.29697	.095
	4th Quartile	1st Quartile	.44351	.010*
		2nd Quartile	.34753	.052
		3rd Quartile	.29697	.095

Communication	1st Quartile	2nd Quartile	.02174	.821
		3rd Quartile	-.26585	.005*
		4th Quartile	-.39069	.040*
	2nd Quartile	1st Quartile	-.02174	.821
		3rd Quartile	-.28759	.010*
		4th Quartile	-.41243	.038*
	3rd Quartile	1st Quartile	.26585	.005*
		2nd Quartile	.28759	.010*
		4th Quartile	-.12484	.527
	4th Quartile	1st Quartile	.39069	.040*
		2nd Quartile	.41243	.038*
		3rd Quartile	.12484	.527
Connections	1st Quartile	2nd Quartile	-.06533	.469
		3rd Quartile	-.19970	.026*
		4th Quartile	-.42221	.018*
	2nd Quartile	1st Quartile	.06533	.469
		3rd Quartile	-.13436	.196
		4th Quartile	-.35687	.056
	3rd Quartile	1st Quartile	.19970	.026*
		2nd Quartile	.13436	.196
		4th Quartile	-.22251	.231
	4th Quartile	1st Quartile	.42221	.018*
		2nd Quartile	.35687	.056
		3rd Quartile	.22251	.231
Representation	1st Quartile	2nd Quartile	.01895	.843
		3rd Quartile	-.19697	.038*
		4th Quartile	-.36212	.056
	2nd Quartile	1st Quartile	-.01895	.843
		3rd Quartile	-.21592	.051
		4th Quartile	-.38107	.054
	3rd Quartile	1st Quartile	.19697	.038*
		2nd Quartile	.21592	.051
		4th Quartile	-.16515	.401
	4th Quartile	1st Quartile	.36212	.056
		2nd Quartile	.38107	.054
		3rd Quartile	.16515	.401

* denotes significance at $p < .05$

Table 13

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Individual Planning Time based on Age

Age (I)	Age (J)	Mean Difference (I – J)	Significance
20-29	30-39	-.145	.497
	40-49	-.369	.079
	50-59	-.610	.003*
	60 +	-.453	.347
30-39	20-29	.145	.497
	40-49	-.224	.238
	50-59	-.465	.012*
	60 +	-.307	.515
40-49	20-29	.369	.079
	30-39	.224	.238
	50-59	-.240	.177
	60 +	-.083	.859
50-59	20-29	.610	.003*
	30-39	.465	.012*
	40-49	.240	.177
	60 +	.157	.737
60+	20-29	.453	.347
	30-39	.307	.515
	40-49	.083	.859
	50-59	-.157	.737

* denotes significance at $p < .05$

Table 14

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Individual Planning Time based on Math Teaching Experience

Math Teaching Experience (I)	Math teaching Experience (J)	Mean Difference (I – J)	Significance
0-9	10-19	-.352	.042*
	20-29	-.216	.265
	30 +	-.582	.018*
10-19	0-9	.352	.042*
	20-29	.136	.542
	30 +	-.231	.393
20-29	0-9	.216	.265
	10-19	-.136	.542
	30+	-.367	.197
30 +	0-9	.582	.018*
	10-19	.231	.393
	20-29	.367	.197

*denotes significance at p < .05

Table 16

Fisher's LSD Multiple Comparisons Testing for Significant Differences between Quartiles of Collaborative Planning Time based on Math Teaching Experience

Math Teaching Experience (I)	Math teaching Experience (J)	Mean Difference (I – J)	Significance
0-9	10-19	.100	.527
	20-29	.048	.786
	30 +	.640	.005*
10-19	0-9	-.100	.527
	20-29	-.052	.797
	30 +	.540	.029*
20-29	0-9	-.048	.786
	10-19	.052	.797
	30+	.592	.023*
30 +	0-9	-.640	.005*
	10-19	-.540	.029*
	20-29	-.592	.023*

*denotes significance at p < .05

Table 17

ANOVA for Quartiles of Individual Planning Time based on Teaching Experience

		Mean Square	F	Significance
Teaching Experience	Between Groups	1.208	1.109	.346
	Within Groups	1.089		

Table 18

ANOVA for Quartiles of Collaborative Planning Time based on Teaching Experience

		Mean Square	F	Significance
Teaching Experience	Between Groups	1.931	1.791	.150
	Within Groups	1.078		

Table 20

Independent T-Test for Significant Differences between Quartiles of Collaborative Planning Times based on WVDE Teaching Experience

				t-test for Equality of Means	
		F	t	Significance (2-tailed)	Mean Difference
Quartiles of Collaborative Planning Times	Equal Variances Assumed	1.343	.297	.767	3.7801
	Equal Variances Not Assumed		.388	.698	3.7801

Table 21

ANOVA for Quartiles of Individual and Collaborative Planning Times based on Highest Degree Completed

		Mean Square	F	Significance
Individual Planning Quartiles	Between Groups	.040	.038	.846
	Within Groups	1.066		
Collaborative Planning Quartiles	Between Groups	.385	.437	.509
	Within Groups	.882		

Table 22

ANOVA for Quartiles of Individual and Collaborative Planning Times based on Recent Conference Attendance

		Mean Square	F	Significance
Individual Planning Quartiles	Between Groups	.152	.142	.706
	Within Groups	1.066		
Collaborative Planning Quartiles	Between Groups	.004	.005	.943
	Within Groups	.883		

Table 26

ANOVA for Mean Frequency of NCTM Process Standards and Traditional Strategies based on Age Groups

		Mean Square	F	Significance
Mean NCTM	Between Groups	.240	1.099	.358
	Within Groups	.219		
Problem Solving	Between Groups	.551	2.170	.073
	Within Groups	.254		
Reasoning & Proof	Between Groups	.156	.565	.689
	Within Groups	.276		
Communication	Between Groups	.321	.955	.433
	Within Groups	.336		
Connections	Between Groups	.268	.875	.479
	Within Groups	.306		
Representation	Between Groups	.467	1.371	.245
	Within Groups	.340		
Traditional	Between Groups	.653	2.071	.085
	Within Groups	.315		

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

Age Groups

			20-29		30-39		40-49		50-59		60+	
			t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
MEAN NCTM	20-29	Equal σ^2 assumed			.276	.783	1.187	.238	-.444	.658	.075	.940
		Equal σ^2 not assumed			.257	.798	1.156	.251	-.427	.670	.056	.957
	30-39	Equal σ^2 assumed	.276	.783			1.223	.224	-.907	.366	-.044	.965
		Equal σ^2 not assumed	.257	.798			1.263	.209	-.951	.343	-.024	.982
	40-49	Equal σ^2 assumed	1.187	.238	1.223	.224			-2.037	*.044	-.501	.618
		Equal σ^2 not assumed	1.156	.251	1.263	.209			-2.035	*.044	-.331	.751
	50-59	Equal σ^2 assumed	-.444	.658	-.907	.366	-2.037	*.044			.307	.759
		Equal σ^2 not assumed	-.427	.670	-.951	.343	2.035	*.044			.198	.849
	60+	Equal σ^2 assumed	.075	.940	-.044	.965	-.501	.618	.307	.759		
		Equal σ^2 not assumed	.056	.957	-.024	.982	-.331	.751	.198	.849		
	20-29	Equal σ^2 assumed			-.905	.368	.642	.522	-1.598	.113	-.782	.438
		Equal σ^2 not assumed			-.861	.392	.628	.532	-1.512	.136	-.598	.569

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

			Age Groups									
			20-29		30-39		40-49		50-59		60+	
			t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
PS	30-39	Equal σ^2 assumed	-.905	.368			1.857	.066	-.845	.400	-.534	.596
		Equal σ^2 not assumed	-.861	.392			1.897	.060	-.861	.391	-.321	.758
	40-49	Equal σ^2 assumed	.642	.522	1.857	.066			-2.754	*.007	-1.207	.231
		Equal σ^2 not assumed	.628	.532	1.897	.060			-2.739	*.007	-.828	.437
	50-59	Equal σ^2 assumed	-1.598	.113	-.845	.400	-2.754	*.007			-.170	.865
		Equal σ^2 not assumed	-1.512	.136	-.861	.391	-2.739	*.007			-.107	.918
	60+	Equal σ^2 assumed	-.782	.438	-.534	.596	-1.207	.231	-.170	.865		
		Equal σ^2 not assumed	-.598	.569	-.321	.758	-.828	.437	-.107	.918		
R&P	20-29	Equal σ^2 assumed			.334	.739	1.29	.200	.770	.443	.035	.972
		Equal σ^2 not assumed			.324	.747	1.288	.202	.771	.443	.029	.977
	30-39	Equal σ^2 assumed	.334	.739			1.155	.250	.532	.596	-.137	.891
		Equal σ^2 not assumed	.324	.747			1.174	.243	.546	.586	-.100	.923
	40-49	Equal σ^2 assumed	1.29	.200	1.155	.250			-.636	.526	-.608	.545
		Equal σ^2 not assumed	1.288	.202	1.174	.243			-.636	.526	-.495	.636

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

			Age Groups									
			20-29		30-39		40-49		50-59		60+	
			t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
	50-59	Equal σ^2 assumed	.770	.443	.532	.596	-.636	.526			-.342	.733
		Equal σ^2 not assumed	.771	.443	.546	.586	-.636	.526			-.280	.788
	60+	Equal σ^2 assumed	.035	.972	-.137	.891	-.608	.545	-.342	.733		
		Equal σ^2 not assumed	.029	.977	-.100	.923	-.495	.636	-.280	.788		
COM	20-29	Equal σ^2 assumed			.520	.604	1.381	.170	-.178	.859	.421	.676
		Equal σ^2 not assumed			.500	.618	1.304	.197	-.173	.863	.288	.782
	30-39	Equal σ^2 assumed	.520	.604			1.022	.309	-.840	.402	.263	.793
		Equal σ^2 not assumed	.500	.618			1.023	.308	-.860	.391	.147	.887
	40-49	Equal σ^2 assumed	1.381	.170	1.022	.309			-1.909	.058	-.138	.890
		Equal σ^2 not assumed	1.304	.197	1.023	.308			-1.924	.056	-.076	.942
	50-59	Equal σ^2 assumed	-.178	.859	-.840	.402	-1.909	.058			.576	.566
		Equal σ^2 not assumed	-.173	.863	-.860	.391	-1.924	.056			.342	.743
	60+	Equal σ^2 assumed	.421	.676	.263	.793	-.138	.890	.576	.566		
		Equal σ^2 not assumed	.288	.782	.147	.887	-.076	.942	.342	.743		

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

			Age Groups									
			20-29		30-39		40-49		50-59		60+	
			t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
CON	20-29	Equal σ^2 assumed			.334	.739	1.265	.209	.015	.988	.790	.434
		Equal σ^2 not assumed			.321	.749	1.277	.205	.015	.988	.632	.547
	30-39	Equal σ^2 assumed	.334	.739			1.166	.246	-.367	.714	.799	.428
		Equal σ^2 not assumed	.321	.749			1.195	.234	-.379	.706	.530	.614
	40-49	Equal σ^2 assumed	1.265	.209	1.166	.246			-1.526	.129	.192	.849
		Equal σ^2 not assumed	1.277	.205	1.195	.234			-1.522	.130	.152	.884
	50-59	Equal σ^2 assumed	.015	.988	-.367	.714	-1.526	.129			.848	.399
		Equal σ^2 not assumed	015	.988	.379	.706	1.522	.130			.641	.543
	60+	Equal σ^2 assumed	.790	.434	.799	.428	.192	.849	.848	.399		
		Equal σ^2 not assumed	.632	.547	.530	.614	.152	.884	.641	.543		
	20-29	Equal σ^2 assumed			.764	.447	.637	525	-.969	.335	-.159	.874
		Equal σ^2 not assumed			.715	.478	.628	.532	-.945	.348	-.127	.903
	30-39	Equal σ^2 assumed	.764	.447			-.051	.960	-2.141	*.034	-.651	.517
		Equal σ^2 not assumed	.715	.478			-.053	.958	-2.248	*.026	-.380	.716

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

			Age Groups									
			20-29		30-39		40-49		50-59		60+	
			t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
REP	40-49	Equal σ^2 assumed	.637	.525	-.051	.960			-1.955	.053	-.495	.622
		Equal σ^2 not assumed	.628	.532	-.053	.958			-1.953	.053	-.363	.728
	50-59	Equal σ^2 assumed	-.969	.335	-2.141	*.034	-1.955	.053			.299	.766
		Equal σ^2 not assumed	-.945	.348	-2.248	*.026	-1.953	.053			.213	.838
	60+	Equal σ^2 assumed	-.159	.874	-.651	.517	-.495	.622	.299	.766		
		Equal σ^2 not assumed	-.127	.903	-.380	.716	-.363	.728	.213	.838		
TRAD	20-29	Equal σ^2 assumed			1.512	.134	1.779	.078	2.735	.007*	.946	.350
		Equal σ^2 not assumed			1.525	131	1.833	.070	2.985	.004*	.593	.573
	30-39	Equal σ^2 assumed	1.512	.134			.301	.764	1.550	.124	.286	.776
		Equal σ^2 not assumed	1.525	131			.303	763	1.605	.111	.175	.867
	40-49	Equal σ^2 assumed	1.779	.078	.301	.764			1.330	.186	.158	.875
		Equal σ^2 not assumed	1.833	.070	.303	763			1.342	.182	.098	.925
	50-59	Equal σ^2 assumed	2.735	.007*	1.550	.124	1.330	.186			-.364	.717
		Equal σ^2 not assumed	2.985	.004*	1.605	.111	1.342	.182			-.255	.807

Table 27

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Age Groups

		Age Groups									
		20-29		30-39		40-49		50-59		60+	
		t	Sig	t	Sig	t	Sig	t	Sig	t	Sig
60+	Equal σ^2 assumed	.946	.350	.286	.776	.158	.875	-.364	.717		
	Equal σ^2 not assumed	.593	.573	.175	.867	.098	.925	-.255	.807		

*denotes significance at $p < .05$

Key: PS = problem solving   R&P = reasoning and proof   COM = communication
CON = connections   REP = representation   TRAD = traditional

Table 28

ANOVA for Mean Frequency of NCTM Process Standards and Traditional Strategies based on Teaching Experience

		Mean Square	F	Significance
Mean NCTM	Between Groups	.113	.511	.675
	Within Groups	.221		
Problem Solving	Between Groups	.141	.542	.654
	Within Groups	.260		
Reasoning & Proof	Between Groups	.296	1.076	.360
	Within Groups	.275		
Communication	Between Groups	.159	.471	.703
	Within Groups	.337		
Connections	Between Groups	.061	.197	.898
	Within Groups	.308		
Representation	Between Groups	.326	.951	.416
	Within Groups	.342		
Traditional	Between Groups	.601	1.897	.131
	Within Groups	.317		

Table 29

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Teaching Experience

			Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
MEAN NCTM	0-9	Equal σ^2 assumed			1.103	.272	.105	.917	-.167	.868
		Equal σ^2 not assumed			1.106	.271	101	.920	-.175	.862
	10-19	Equal σ^2 assumed	1.103	272			-.805	.422	-1.103	.273
		Equal σ^2 not assumed	1.106	.271			-.774	.441	-1.121	.266
	20-29	Equal σ^2 assumed	.105	.917	-.805	.422			-.222	.825
		Equal σ^2 not assumed	.101	920	-.774	.441			-.238	.812
	30+	Equal σ^2 assumed	-.167	.868	-1.103	.273	-.222	.825		
		Equal σ^2 not assumed	-.175	.862	-1.121	.266	-.238	.812		
PS	0-9	Equal σ^2 assumed			.429	.668	-.246	.806	-.967	.335
		Equal σ^2 not assumed			.430	.668	-.240	.811	-1.005	.318
	10-19	Equal σ^2 assumed	.429	.668			-.614	.540	-1.355	.178
		Equal σ^2 not assumed	.430	.668			-.596	.552	-1.378	.173
	20-29	Equal σ^2 assumed	-.246	.806	-.614	.540			-.623	.535
		Equal σ^2 not assumed	-.240	.811	-.596	.552			-.659	.511

Table 29

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Teaching Experience

			Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
	30+	Equal σ^2 assumed	-.967	.335	-1.355	.178	-.623	.535		
		Equal σ^2 not assumed	-1.005	.318	-1.378	.173	-.659	.511		
R&P	0-9	Equal σ^2 assumed			1.465	.145	.989	.325	-.204	.839
		Equal σ^2 not assumed			1.464	.145	.963	.338	-.234	.816
	10-19	Equal σ^2 assumed	1.465	.145			-.282	.778	-1.465	.146
		Equal σ^2 not assumed	1.464	.145			-.277	.782	-1.679	.096
	20-29	Equal σ^2 assumed	.989	.325	-.282	.778			-1.030	.306
		Equal σ^2 not assumed	.963	.338	-.277	.782			-1.151	.253
	30+	Equal σ^2 assumed	-.204	.839	-1.465	.146	-1.030	.306		
		Equal σ^2 not assumed	-.234	.816	-1.679	.096	-1.151	.253		
	0-9	Equal σ^2 assumed			.447	655	-.716	.475	.272	.786
		Equal σ^2 not assumed			.448	.654	-.694	.489	.267	.791
	10-19	Equal σ^2 assumed	.447	.655			-1.108	.270	-.069	.945
		Equal σ^2 not assumed	.448	.654			-1.067	.289	-.066	.948

Table 29

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Teaching Experience

Teaching Experience

			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
COM	20-29	Equal σ^2 assumed	-.716	.475	-1.108	.270			.780	.437
		Equal σ^2 not assumed	-.694	.489	-1.067	.289			.804	.424
	30+	Equal σ^2 assumed	.272	.786	-.069	.945	.780	.437		
		Equal σ^2 not assumed	.267	.791	-.066	.948	.804	.424		
CON	0-9	Equal σ^2 assumed			762	.448	.217	.829	.437	.663
		Equal σ^2 not assumed			.762	.447	.212	.833	.464	.644
	10-19	Equal σ^2 assumed	.762	.448			-.432	.666	-.194	.847
		Equal σ^2 not assumed	.762	.447			-.421	.675	-.202	.841
	20-29	Equal σ^2 assumed	.217	.829	-.432	.666			.195	.846
		Equal σ^2 not assumed	.212	.833	-.421	.675			.208	.836
	30+	Equal σ^2 assumed	.437	.663	-.194	.847	.195	.846		
		Equal σ^2 not assumed	.464	.644	-.202	.841	.208	.836		

Table 29

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Teaching Experience

			Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
REP	0-9	Equal σ^2 assumed			1.472	.143	.256	.799	-.338	.736
		Equal σ^2 not assumed			1.473	.143	.247	.805	-.346	.731
	10-19	Equal σ^2 assumed	1.472	.143			-.963	.338	-1.544	.126
		Equal σ^2 not assumed	1.473	.143			-.931	.354	-1.558	.124
	20-29	Equal σ^2 assumed	.256	.799	-.963	.338			-.482	.631
		Equal σ^2 not assumed	.247	.805	-.931	.354			-.511	.611
	30+	Equal σ^2 assumed	-.338	.736	-1.544	.126	-.482	.631		
		Equal σ^2 not assumed	-.346	.731	-1.558	.124	-.511	.611		
	0-9	Equal σ^2 assumed			1.754	082	.158	.875	1.876	.063
		Equal σ^2 not assumed			1.761	.080	.156	.877	1.754	.085
	10-19	Equal σ^2 assumed	1.754	082			-1.379	.170	.690	.492
		Equal σ^2 not assumed	1.761	.080			-1.333	.185	.616	.541

Table 29

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Teaching Experience

			Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
TRAD	20-29	Equal σ^2 assumed	.158	.875	-1.379	.170			1.538	.128
		Equal σ^2 not assumed	.156	.877	-1.333	.185			1.508	.136
	30+	Equal σ^2 assumed	1.876	.063	.690	.492	1.538	.128		
		Equal σ^2 not assumed	1.754	.085	.616	.541	1.508	.136		

*denotes significance at $p < .05$

Key: PS = problem solving; R&P = reasoning and proof; COM = communication; CON = connections; REP = representation; TRAD = traditional

Table 30

ANOVA for Mean Frequency of NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

		Mean Square	F	Significance
Mean NCTM	Between Groups	.158	.711	.546
	Within Groups	.222		
Problem Solving	Between Groups	.025	.094	.963
	Within Groups	.266		
Reasoning & Proof	Between Groups	.147	.523	.667
	Within Groups	.281		
Communication	Between Groups	.340	1.005	.391
	Within Groups	.338		
Connections	Between Groups	.329	1.075	.360
	Within Groups	.306		
Representation	Between Groups	.159	.458	.712
	Within Groups	.348		
Traditional	Between Groups	.370	1.151	.329
	Within Groups	.321		

Table 31

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

			Math Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
MEAN NCTM	0-9	Equal σ^2 assumed			1.100	.273	-.253	.800	.994	.322
		Equal σ^2 not assumed			1.087	.280	-.227	.821	1.117	.273
	10-19	Equal σ^2 assumed	1.100	.273			-.982	.329	.190	.850
		Equal σ^2 not assumed	1.087	.280			-.955	.343	.207	.837
	20-29	Equal σ^2 assumed	-.253	.800	-.982	.329			.920	.361
		Equal σ^2 not assumed	-.227	.821	-.955	.343			1.034	.306
	30+	Equal σ^2 assumed	.994	.322	.190	.850	.920	.361		
		Equal σ^2 not assumed	1.117	.273	.207	.837	1.034	.306		
	0-9	Equal σ^2 assumed			.315	.753	-.218	.828	.323	.747
		Equal σ^2 not assumed			.311	.757	-.198	.844	.359	.722
	10-19	Equal σ^2 assumed	.315	.753			-.409	.687	.089	.929
		Equal σ^2 not assumed	.311	.757			-.395	.694	.097	.924

Table 31

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

			Math Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
PS	20-29	Equal σ^2 assumed	-.218	.828	-.409	.687			.392	.696
		Equal σ^2 not assumed	-.198	.844	-.395	.694			.436	.665
	30+	Equal σ^2 assumed	.323	.747	.089	.929	.392	.696		
		Equal σ^2 not assumed	.359	.722	.097	.924	.436	.665		
R&P	0-9	Equal σ^2 assumed			1.185	.238	-.022	.982	.254	.800
		Equal σ^2 not assumed			1.166	.246	-.021	.983	.339	.736
	10-19	Equal σ^2 assumed	1.185	.238			-.901	.370	-.568	.572
		Equal σ^2 not assumed	1.166	.246			-.894	.374	-.690	.493
	20-29	Equal σ^2 assumed	-.022	.982	-.901	.370			.235	.815
		Equal σ^2 not assumed	-.021	.983	-.894	.374			.274	.785
	30+	Equal σ^2 assumed	.254	.800	-.568	.572	.235	.815		
		Equal σ^2 not assumed	.339	.736	-.690	.493	.274	.785		

Table 31

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

Math Teaching Experience

			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
COM	0-9	Equal σ^2 assumed			1.066	.288	-.446	.656	1.251	.213
		Equal σ^2 not assumed			1.113	.268	-.413	.681	1.226	.231
	10-19	Equal σ^2 assumed	1.066	.288			-1.194	.235	.533	.596
		Equal σ^2 not assumed	1.113	.268			-1.148	.255	.501	.620
	20-29	Equal σ^2 assumed	-.446	.656	-1.194	.235			1.263	.212
		Equal σ^2 not assumed	-.413	.681	-1.148	.255			1.314	.195
	30+	Equal σ^2 assumed	1.251	.213	.533	.596	1.263	.212		
		Equal σ^2 not assumed	1.226	.231	.501	.620	1.314	.195		
	0-9	Equal σ^2 assumed			1.095	.275	-.096	.923	1.535	.127
		Equal σ^2 not assumed			1.107	.271	-.092	.927	1.900	.066
	10-19	Equal σ^2 assumed	1.095	.275			-.909	.366	.737	.463
		Equal σ^2 not assumed	1.107	.271			-.891	.376	.832	.409

Table 31

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

			Math Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
CON	20-29	Equal σ^2 assumed	-.096	.923	-.909	.366			1.370	.176
		Equal σ^2 not assumed	-.092	.927	-.891	.376			1.550	.127
	30+	Equal σ^2 assumed	1.535	.127	.737	.463	1.370	.176		
		Equal σ^2 not assumed	1.900	.066	.832	.409	1.550	.127		
REP	0-9	Equal σ^2 assumed			.943	.347	-.267	.790	.657	.512
		Equal σ^2 not assumed			.953	.343	-.236	.814	.659	.516
	10-19	Equal σ^2 assumed	.943	.347			-.883	.379	.009	.993
		Equal σ^2 not assumed	.953	.343			-.848	.399	.009	.993
	20-29	Equal σ^2 assumed	-.267	.790	-.883	.379			.646	.521
		Equal σ^2 not assumed	-.236	.814	-.848	.399			.699	.488
	30+	Equal σ^2 assumed	.657	.512	.009	.993	.646	.521		
		Equal σ^2 not assumed	.659	.516	.009	.993	.699	.488		

Table 31

Independent T-Tests Comparing NCTM Process Standards and Traditional Strategies based on Math Teaching Experience

			Math Teaching Experience							
			0-9		10-19		20-29		30+	
			t	Sig	t	Sig	t	Sig	t	Sig
TRAD	0-9	Equal σ^2 assumed			..918	.360	-.176	.860	1.614	.109
		Equal σ^2 not assumed			1.009	.315	-.164	.870	1.423	.167
	10-19	Equal σ^2 assumed	.918	.360			-.873	.385	1.075	.286
		Equal σ^2 not assumed	1.009	.315			-.825	.412	.895	.379
	20-29	Equal σ^2 assumed	-.176	.860	-.873	.385			1.353	.181
		Equal σ^2 not assumed	-.164	.870	-.825	.412			1.339	.188
	30+	Equal σ^2 assumed	1.614	.109	1.075	.286	1.353	.181		
		Equal σ^2 not assumed	1.423	.167	.895	.379	1.339	.188		

*denotes significance at $p < .05$

Key: PS = problem solving R&P = reasoning and proof COM = communication
CON = connections REP = representation TRAD = traditional

CURRICULUM VITAE

KERRI COLLEEN LOOKABILL

EDUCATION

Marshall University- Doctor of Education in Curriculum and Instruction, 2008
Marshall University- Education Specialist, 2006
University of Virginia- Masters in Education, 1996
Concord College- Bachelor of Science in Mathematics, 1991
Concord College- Bachelor of Science in Education, 1991

CERTIFICATION

State of West Virginia, Mathematics 5-12

PROFESSIONAL EXPERIENCE

1991-1998	Teacher in Campbell County, Virginia
1998-2000	Teacher in Raleigh County, West Virginia
1998-2000	Adjunct Instructor for Concord College
2000-2005	Instructor of Mathematics for Mountain State University
2005-Present	Assistant Professor of Mathematics for Mountain State University