

DETERMINING TEACHERS' BEHAVIORS CONCERNING THE NCTM STANDARDS IN  
LOW AND HIGH PERFORMING RURAL HIGH SCHOOLS IN KANSAS

by

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AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Curriculum and Instruction  
College of Education

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

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## **Abstract**

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This two-phase study used both quantitative and qualitative data from four main sources: survey, interview, observation, and collection of artifacts. Phase I surveyed all mathematics teachers in high performing and low performing rural high schools throughout the state of Kansas. Data collected in Phase I were used to examine differences and similarities in teaching practices of teachers from high and low performing schools. During Phase II qualitative data were collected and analyzed to further explore any existing patterns among high performing and low performing schools. Results from teachers in high and low performing schools were compared and contrasted to determine if there were differences between the teaching practices that were demonstrated by each group of teachers.

Results of surveys, interviews, observations, and artifacts revealed teachers in high performing schools used a variety of different representations to teach and assess a topic while those teachers from low performing schools used one or two representations. Students from high performing schools had more frequent opportunities to communicate with the teacher to gain additional assistance in learning the mathematics content. Teachers in high performing schools also used formal assessment strategies as part of the learning process more consistently than their counterparts from low performing schools. Results from interviews, observations, and artifacts reveal that teachers in high and low performing schools implement teaching practices aligned with the algebra content standards in a very similar manner.

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Major Professor  
Dr. Gail Shroyer

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## Table of Contents

List of Figures .....	x
List of Tables .....	xi
Acknowledgements .....	xiii
CHAPTER 1 - Introduction .....	1
Mathematics Standards in K-12 .....	3
Introduction .....	3
Implementation .....	4
Rural Schools .....	5
Statement of the Problem .....	6
Focus of Study .....	6
Research Questions .....	6
Substantive Expectations .....	7
Method .....	7
Significance of the Study .....	8
Delimitations of the Study .....	9
Limitations of the Study .....	10
Definition of Terms .....	10
Summary .....	12
CHAPTER 2 - REVIEW OF LITERATURE .....	14
Introduction .....	14
<i>Principles and Standards</i> for School Mathematics .....	14
Brief History .....	14
Vision of the Standards .....	16
Research Related to the Standards .....	20
Teachers and the Standards .....	22
Opposition to the NCTM Standards .....	25
Summary of Principles and Standards .....	27

Rural Schools .....	28
Summary .....	31
CHAPTER 3 - Methodology .....	32
Overview .....	32
Research Design .....	32
The Setting .....	34
The Participants .....	35
Data Collection .....	41
PHASE I .....	41
The Survey Instrument .....	41
PHASE II .....	42
The Interview Protocol .....	42
Observation Protocol .....	43
Artifacts .....	45
Data Analysis .....	46
PHASE I .....	46
Survey Analysis .....	46
PHASE II .....	47
Survey Analysis .....	47
Interview Analysis .....	47
Observation Analysis .....	48
Artifact Analysis .....	49
Instrument Validity .....	52
Survey .....	52
Ensuring Trustworthiness .....	53
Summary .....	55
CHAPTER 4 - Results .....	56
Introduction .....	56
PHASE I – Survey Analysis .....	57
Teachers at High Performing Schools .....	57
Demographic Data .....	57

Practices Aligned with the NCTM Process Standards in High Performing Schools	59
Teachers at Low Performing Schools .....	66
Demographic Data of Teachers at Low Performing Schools .....	66
Practices Aligned with the NCTM Process Standards in Low Performing Schools	67
Comparison of Survey Results between Teachers at High and Low Performing Schools	
.....	73
PHASE II .....	74
Survey Results .....	75
Comparison of Matched Pairs.....	75
Teacher A and Teacher B .....	75
Teacher C and Teacher D .....	77
Teacher E and Teacher F .....	78
Teacher G and Teacher H .....	80
Summary of Survey Results.....	82
Interview Results .....	83
Teachers at High Performing Schools .....	83
Teachers at Low Performing Schools .....	87
Comparison of Matched Pairs.....	90
Teacher A and Teacher B .....	90
Teacher C and Teacher D .....	91
Teacher E and Teacher F .....	92
Teacher G and Teacher H .....	92
Summary of Interview Results.....	93
Observation Results .....	95
Teachers at High Performing Schools .....	95
Teacher A.....	95
Teacher C.....	97
Teacher E.....	98
Teacher G.....	100
Teachers at Low Performing Schools.....	101
Teacher B.....	101

Teacher D.....	103
Teacher F .....	105
Teacher H.....	106
Comparison of Matched Pairs.....	108
Teacher A and Teacher B .....	108
Teacher C and Teacher D .....	110
Teacher E and Teacher F .....	112
Teacher G and Teacher H .....	114
Summary of Observations.....	115
Artifact Results .....	118
Teachers at High Performing Schools .....	118
Teachers at Low Performing Schools.....	120
Comparison of Matched Pairs.....	121
Teacher A and Teacher B .....	121
Teacher C and Teacher D .....	122
Teacher E and Teacher F .....	123
Teacher G and Teacher H .....	124
Summary of Artifacts.....	124
Triangulation.....	125
Teachers at High Performing Schools .....	125
Teachers at Low Performing Schools.....	129
Summary of Triangulation .....	132
Summary.....	133
CHAPTER 5 - Conclusions .....	134
Introduction.....	134
Summary of Results Related to Research Questions.....	136
Question 1 .....	136
Question 2 .....	139
Question 3 .....	140
Question 4.....	142
Discussion.....	143



Discussion of Results Associated with Teacher Practices and the Principles and Standards .....	143
Discussion of Results of Teacher Practices Associated with the Principles.....	146
Conclusions.....	148
Recommendations for Further Research.....	152
General Research .....	152
Mathematics Achievement Research.....	153
Rural Schools Research .....	154
Summary.....	154
References.....	156
Appendix A - Teacher Survey Letter.....	162
Appendix B - Standards-based practices survey.....	163
Appendix C - Interview Protocol.....	165
Appendix D - Pre/Post Interview Protocol .....	166
Appendix E - Observation Protocol.....	167
Appendix F - Artifact Collection List.....	172

## List of Figures

Figure 4-1: Teacher G Explaining Slope .....	85
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## List of Tables

Table 3.1: Demographic Comparison of School A and B .....	35
Table 3.2: Comparison of Characteristics of Teacher A and B .....	36
Table 3.3: Demographic Comparison of School C and D .....	37
Table 3.4: Comparison of Characteristics of Teacher C and D .....	37
Table 3.5: Demographic Comparison of School E and F .....	38
Table 3.6: Comparison of Characteristics of Teacher E and F .....	39
Table 3.7: Demographic Comparison of School G and H .....	39
Table 3.8: Comparison of Characteristics of Teacher G and H .....	40
Table 3.9: Characteristics of a Standards-based classroom: Process Standards .....	51
Table 3.10: Characteristics of a Traditional Classroom .....	52
Table 3.11: Characteristics of a Standards-based classroom: Content Standards .....	52
Table 4.1: Years of Experience of Teachers at High Performing Schools .....	57
Table 4.2: Coursework of Teachers at High Performing Schools .....	58
Table 4.3: Number of Students in Class at High Performing Schools .....	58
Table 4.4: Demographics vs. Teaching Practices in High Performing Schools .....	59
Table 4.5: Demographics vs. Teaching Practices in High Performing Schools (Female) .....	60
Table 4.6: Demographics vs. Teaching Practices in High Performing Schools (Male) .....	61
Table 4.7: Standards-Based Teaching Practices in High Performing Schools .....	62
Table 4.8: Student Activities in High Performing Schools .....	63
Table 4.9: Assessment Practices in High Performing Schools .....	64
Table 4.10: Teaching Practices in High Performing Schools .....	65
Table 4.11: Years of Teaching Experience at Low Performing Schools .....	66
Table 4.12: Level of Mathematics Education of Teachers in Low Performing Schools .....	67
Table 4.13: Demographics vs. Teaching Practices in Low Performing Schools .....	68
Table 4.14: Demographics vs. Teaching Practices in Low Performing Schools (Female) .....	69
Table 4.15: Standards-Based Teaching Practices in Low Performing Schools .....	70
Table 4.16: Student Activities in Low Performing Schools .....	71

Table 4.17: Assessment Practices of Teachers in Low-Performing High Schools.....	72
Table 4.18: Teaching Practices in Low-Performing Schools .....	73
Table 4.19: Comparison of Classroom Practices of Teacher A and B .....	76
Table 4.20: Comparison of Classroom Practices of Teacher C and D .....	77
Table 4.21: Comparison of Classroom Practices of Teacher E and F .....	79
Table 4.22: Comparison of Classroom Practices of Teacher G and H .....	81
Table 4.23: Survey Comparisons.....	82
Table 4.24: Piecewise-defined functions .....	102
Table 4.25: Observed Practices of Teachers A and B .....	109
Table 4.26: Observed Practices of Teachers C and D .....	111
Table 4.27: Observed Practices of Teachers E and F .....	113
Table 4.28: Observed Practices of Teachers G and H .....	115
Table 4.29: Data Collected from Teachers at High Performing Schools .....	128
Table 4.30: Data Collected from Teachers at Low Performing Schools .....	131

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## CHAPTER 1 - Introduction

Over the past fifty years, mathematics education in the United States has changed dramatically. In 2000, the National Council of Teachers of Mathematics (NCTM) released the *Principles and Standards for School Mathematics* (hereafter referred to as the *Principles and Standards*). In the first few pages of *Principles and Standards*, the purpose is clear; our students “deserve and need the best mathematics education possible...” (p. 4). These goals set forth in the *Principles and Standards* are ambitious. With consistent and systematic implementation, these standards hold the potential to positively influence the mathematics education of students in the U.S. and across the world.

Just as much research preceded the publication of *Principles and Standards*, much research needs to follow to determine the impact of *Principles and Standards* on classroom practice and student achievement (Lester & Ferrini-Mundy, 2004). More than 15 years after the release of *Curriculum and Evaluation Standards for School Mathematics* in 1989 and over five years after the release of *Principles and Standards*, educators and researchers alike are asking whether the standards-based reform is making a difference in the type or quality of instruction experienced by students (Porter, 2001). Ultimately, the impact *Principles and Standards* are having on student achievement must be assessed. It is critical to understand the purposes and goals of the *Principles and Standards* as well as the history and research leading up to their development before one can fully assess the impact the *Principles and Standards* might have on student achievement.

The success of *Principles and Standards* and their impact on student learning is directly related to the classroom teacher. Mathematics teachers at all levels must embrace the ideals and implement the practices aligned with the vision of the NCTM *Principles and Standards* in their classrooms. Most importantly, the overarching goal of *Principles and Standards* is to make mathematics accessible and meaningful to all students; including those students educated in small rural classrooms. The rural classrooms are rarely impacted by national reform movements, yet nearly one third of all students are educated in a rural setting (Beeson & Strange, 2003). Therefore, to investigate the potential influence of *Principles and Standards* studying the rural

environment and the possible benefits and obstacles to implementing standards-based practices in the rural environment must also be examined.

In 2001, a review of ERIC Database and Dissertation Abstracts International found fewer than twenty-five studies on rural mathematics education of which only a handful drew conclusions relevant to rural practice (Howley, 2005). Yet one quarter of the nations' population live in rural areas (Schultz, 2002) and one fifth of all mathematics lessons are taught in rural and/or small schools (Silver & Castro, 2002). Traditional arguments suggest small schools are less effective and less efficient than larger schools (Haller, 1993). On National Assessment of Educational Progress (NAEP) tests, the performance of urban students is consistently better than those students from rural and small towns (Shultz, 2002). Since mathematics serves as a "critical filter" with the potential to reward successful individuals with higher status and pay and is essential for making informed consumer and voting choices, it is important that students educated in rural schools receive the best mathematics education possible (Lubienski, 2001).

In Kansas, over one half of all schools are considered rural by the National Center for Educational Statistics (NCES, 2006a). Over forty percent of rural schools have a majority of their students scoring below Proficient on the state mathematics assessment. Approximately 35% of all rural schools achieve Standard of Excellence on the Kansas Mathematics Assessment each year, but only twenty-one percent of all rural schools met the Standard of Excellence two consecutive years during the 2003-2005 school years. At the same time 25% of non-rural schools achieved Standard of Excellence in Mathematics; however, fewer than ten percent achieved Standard of Excellence for two consecutive years. With more than fifty percent of all high schools in Kansas considered rural, what are those schools which achieve such success doing differently concerning the *Principles and Standards* than those who are not?

Beeson and Strange (2003) labeled Kansas as a state which scores in the upper half of their Importance Gauge based on percent of population considered rural and percent of public schools in rural areas, and the lower half on the Urgency Gauge, based on percent of population while urgency gauge is based on students' socioeconomic status, teacher salary, computers and technology available, and parental support. This suggests that in spite of the sparse population and remotely located schools and communities, there are some "good things" happening in these schools in Kansas. It is necessary to determine what these "good things" are so that we may

continue to build upon them and share those ideas with other schools and teachers which are not experiencing the same levels of success. This study contributes to the knowledge base of rural education and mathematics education with the reform movement by determining the level of implementation of standards-based practices in high and low performing high schools in rural Kansas.

## **Mathematics Standards in K-12**

### ***Introduction***

In the 1980s the NCTM Board of Directors determined that the mathematics curriculum for elementary and secondary schools in the United States was insufficient (Furner, 2000). This began a long process of research, *Agenda for Action*, *A Nation at Risk*, and *Adding it Up*, to ultimately develop a document to improve mathematics education (Schultz, 2002). The 1989 release of *Curriculum and Evaluation Standards for School Mathematics* and the 2000 release of the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* were intended to be a resource and guide for those involved in the changes related to improving mathematics education (NCTM, 2000). To support the use of the Standards in the classroom, NCTM also published *Professional Standards for Teaching Mathematics* (1991) and *Assessment Standards for School Mathematics* (1995). The ideal classroom depicted in the first pages of the *Principles and Standards* document asks all mathematics educators to “imagine a school where all students have access to high-quality, engaging mathematics instruction.” (NCTM, 2000, p. 3) Since their release, there has been a greater focus on trying to achieve this ideal learning environment for all students. The vision of the *Principles and Standards* assumes that students will be engaged in a wide variety of meaningful and challenging mathematics topics; represent mathematics in various ways; investigate, collect data, make and justify their conjectures based on evidence; become effective problem solvers; work collaboratively using technology and manipulatives to solve non-routine problems; and communicate their ideas effectively to others.

NCTM is not alone in its effort to establish standards for mathematics education. The National Research Council (NRC) and many other organizations across disciplines advocate standards-based practices in order to improve students' content knowledge, processes, skills, motivation, and disposition. A standard is a statement of what a person should be able to do or a



statement of outcomes which hold a school accountable (Tate, 2004). The mathematics standards, put forth by NCTM, are a vision of what is needed for all students to become literate in mathematics (NRC, 2002). *Principles and Standards* emphasize basic concepts as well as the overarching concepts that will aid students in becoming productive members of society.

Despite the enormous amount of time and energy spent in the development of the *Principles and Standards*, there has been little research about the impact and influence the *Principles and Standards* have had on teaching practices and student learning (Ferrini-Mundy, 2004). Without the support and cooperation of active classroom teachers, *Principles and Standards* will never achieve the desired impact on student learning.

### ***Implementation***

The goals and vision set forth by the NCTM *Principles and Standards* are ambitious; having the potential to impact school mathematics in an extraordinary manner. “Competent and knowledgeable teachers who can integrate instruction with assessment . . . classrooms with ready access to technology, and a commitment to both equity and excellence” are required in order to achieve this vision set forth before us (NCTM, 2000, p.3). First, educators must raise expectations for all students and then carry this higher expectation to curriculum, teaching, learning, and assessment. The *Principles and Standards* place much of the responsibility for student learning on the classroom teacher as students learn through the experiences the teacher provides. “Effective teaching requires knowing and understanding mathematics, students as learners and pedagogical strategies” (p. 17). When teachers understand the big ideas of mathematics and are able to represent them as a coherent whole, they will provide opportunities for students to engage in meaningful problem-solving, investigations, create conjectures, and then justify their results. The final result will be an atmosphere that encourages learning aligned with the vision outlined in the Standards documents.

Teachers must know and understand higher level mathematics as well as the mathematics their students are learning. By implementing standards-based practices, teachers must assist students in making connections from previous knowledge to new concepts. When teachers understand the big ideas and represent mathematics as a connected whole, students will become more appreciative of the mathematics and gain a better understanding of the concepts. In addition, a standards-based classroom is a community where all ideas are respected. Students are

encouraged to think critically, explain their reasoning, and reflect upon their learning in a challenging yet supportive environment (NCTM, 2000).

In many rural schools across the nation, the entire mathematics department may consist of one teacher implying that mathematics colleagues and opportunities to share ideas are in short supply (Silver & Castro, 2002). This phenomenon indicates that a single teacher has an incredible impact on students' dispositions toward mathematics. In addition, teachers' instructional practices are characteristic of their behavior, notions, beliefs, preferences, and conscious and unconscious beliefs that may have come from previous experience which inevitably impact students' learning (Thompson, 1984). If schools are going to improve the quality of mathematics education, then teachers themselves must integrate the message of *Principles and Standards* into the classroom.

### **Rural Schools**

Rural communities, in particular rural schools, provide a unique environment. The way of life, cultures, politics, economies, and close-knit communities are important issues to be addressed. Members of rural communities view their communities and schools much differently than their urban counterparts. Rural people believe there are strengths in the rural schools because of stronger community ties and stronger purpose (Howley, 2003; Howley & Gunn, 2003). This more intimate environment of the smaller rural schools increases student engagement which may in turn increase student achievement (Overbay, 2003).

There are also disadvantages unique to the rural school environment. Traditional arguments suggest small schools are less effective and less efficient than larger schools (Haller, 1993). Rural schools tend to be very isolated causing difficulties recruiting and retaining highly trained teachers. In addition, Haller (1993) found that many rural schools are unable to provide the same equipment, facilities, and technology that larger schools can provide for their students. Smaller schools do not have enough teachers to offer as many upper level courses as urban schools. In addition, scheduling and funding for ITV courses can be very difficult. Yet many members of small rural communities would not trade the rural educational experience for the supposed increased opportunities found in a larger school.

## **Statement of the Problem**

A small percentage of rural high schools in Kansas achieve Standard of Excellence in mathematics consistently. At the time of the study, Standard of Excellence in mathematics was achieved by at least 15% of students scoring Exemplary and no more than 15% of students scoring Unsatisfactory on the state assessment. It is expected that 40% of students will score Advanced or above, 70% score Proficient or above, and 85% will score Basic or above on the assessment (KSDE, 2006). A much larger percentage of rural high schools in Kansas, consistently have at least 50% of students scoring at Basic or below on the state mathematics assessment. Despite various efforts to integrate standards-based practices in mathematics classrooms across the country, and despite evidence suggesting standards-based practices improve student learning (NCTM, 2000), some teachers do not embrace the message of *Principles and Standards* or implement standards-based practices in their classrooms. There are many factors that may contribute to students' success or lack thereof on state assessments. In this study, the investigator examined the extent to which teachers in high and low performing schools in Kansas demonstrate teaching practices in alignment with the NCTM *Principles and Standards* through examining behaviors of high school mathematics teachers.

## **Focus of Study**

The purpose of this study was to determine the extent to which mathematics teachers in high and low performing rural high schools in Kansas demonstrate teaching practices in alignment with the vision of the NCTM *Principles and Standards*. The researcher investigated the various levels of implementation of standards-based practices in order to find possible patterns related to student success on the state assessment.

## **Research Questions**

The NCTM Standards were developed to make mathematics accessible and meaningful to all students; however, the Standards cannot be effective if teachers do not embrace the ideals and implement the practices aligned with the Standards. The purpose of this study was to determine the extent to which mathematics teachers in high and low performing rural high schools demonstrate teaching practices in alignment with the vision of the NCTM Standards by

examining behaviors of high school mathematics teachers. The following questions are the specific foci of the study:

1. To what extent do teachers in high performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
2. To what extent do teachers in high performing rural high schools implement teaching practices aligned with the NCTM algebra content standards?
3. To what extent do teachers in low performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
4. To what extent do teachers in low performing rural high schools implement teaching practices aligned with the NCTM algebra content standards?

### **Substantive Expectations**

It is very difficult to determine if the NCTM Standards documents are the key element in increasing student learning. The researcher believed that those teachers implementing standards-based practices into the classroom would increase students' learning and understanding of mathematics, thus scoring higher on the Kansas mathematics assessment. Student learning is never the result of just one teacher; there have been many teachers who have influenced each student's success in mathematics which were not taken into account in this study. There are also many variables that have a potential effect on teacher behavior that were not considered such as the amount and type of professional development, school finance issues, and administrative support. The researcher expected that the majority of teachers, from both high and low performing schools, would agree with the vision set forth by *Principles and Standards* but would not be implementing many standards-based practices in the classroom. The achievement of students on state assessments tests could then be related to other variables beyond the scope of this study.

### **Method**

Approximately 200 mathematics teachers from 124 rural high schools in Kansas were asked to participate in Phase I of the study. The high schools were chosen based on results from the Kansas Mathematics Assessment during 2003-2005. Approximately one third of the schools in the study, which had met the Standard of Excellence on the mathematics assessment two

consecutive years, were labeled high performing. Two thirds of the remaining high schools were considered low performing for the purpose of this study, they had an average of 50% of their students achieving Basic or Unsatisfactory on the state math assessment for two consecutive years.

The study included quantitative methods in Phase I followed by a more qualitative approach in Phase II. A survey instrument was utilized in Phase I to gather information about teachers, their schools, class sizes, and classroom practices. Data from the survey were analyzed descriptively to gain an overall understanding of teaching practices in high and low performing schools as well as to look for patterns in teaching practices between high achieving and low achieving schools. The data were also used to compare practices of teachers in each group. Using information gathered from the survey in conjunction with data gathered from the KSDE website, four matched pairs of schools were created for Phase II of the study. Interviews, observations, and collection of artifacts from high school mathematics teachers from the four sets of purposefully selected high schools were used to gain a more indepth understanding of teachers' views concerning *Principles and Standards* and the consequent implementation into the classroom. Classroom practices of teachers from the two groups were compared to discover relationships between student achievement and teachers' classroom practices. This second phase involved interviewing, observing, and obtaining teacher work samples from each high school teacher covering a unit on functions during the fall 2006 semester. Data from interviews, observations, and teacher work samples were then compared across high and low performing schools.

### **Significance of the Study**

There have been very few studies analyzing standards-based mathematics in rural high schools, fewer than twenty five in a review conducted by Howley (2001). This study adds to the literature specifically for the state of Kansas. In addition, this study focused specifically on the implementation of mathematics standards in rural schools.

Thompson (1984) asserts that failing to recognize the role of the teacher's conceptions in classroom instruction could misguide professional development. In addition, Porter (2001) asks whether the standards-based reform is making a difference in the type or quality of instruction experienced by students. By investigating the relationship between the implementation of the

Standards into the classroom and achievement on state assessments, the study helps determine the effectiveness of the standards-based movement in rural schools in Kansas. Possible professional development needs of pre-service and in-service teachers regarding *Principles and Standards* and effective instruction in rural schools can be identified and implemented.

Personal experience has led the researcher to believe in the value and advantages of a rural education as well as understand the difficulties and struggles that many rural teachers and students face. The researcher attended a rural school K-12 and then after receiving a degree in math education, taught at a rural school for three years. Personal experience has led her to believe in the significance and rewards of a rural education.

Furthermore, much of the researcher's graduate work was based on the *Principles and Standards* with much emphasis on the reform movement and standards-based practices. The researcher understands the vision and the potential benefits of the Standards and hopes to pass these on to other mathematics educators. Knowing that the responsibilities of the rural teacher do not always allow for the creativity and time required for preparation of reform-based lessons, the researcher looked for teachers whose students were successful on state assessments to determine the level at which they were integrating standards-based practices into the classroom. The researcher believed those students experiencing consistent success on the state assessments, would be in classrooms which were implementing more standards-based practices.

### **Delimitations of the Study**

This study is bounded by the following delimitations:

1. The study involved rural schools in Kansas where the student population is predominantly white and middle class.
2. The participants were limited to high school mathematics teachers.
3. The only major influence considered to effect teachers' behaviors was the standards-based movement focused on *Principles and Standards*.
4. Interview, observations, and teacher artifacts were used to document the link between teachers' classroom behaviors and student achievement.

## **Limitations of the Study**

As with any study, there were several limitations. It is very difficult to determine if the Standards were the key element in increasing student learning. However, the researcher believed that those teachers implementing standards-based practices into the classroom would increase the student's learning and understanding of mathematics, thus scoring higher on the Kansas mathematics assessment.

In addition, this study was conducted regionally using the Kansas State Mathematics Assessment as the overarching assessment which may cause generalizations to a larger geographic area to be difficult. Results may not be applicable to urban or rural areas that include more racial diversity and different socio-economic levels. By choosing to interview and observe teachers, the number of teachers involved in the study was less than if the researcher had used strictly quantitative methods. Eight teachers may not be enough to adequately represent the range of beliefs and practices related to the implementation of standards-based practices in Kansas.

A low response rate on the surveys was a potential limitation to the given study by affecting the number of matched pairs that could be made. The original plan was to study five matched pairs but ultimately only four were identified. The low response rate on the surveys may not be sufficient to make generalizations to the entire population of teachers in rural Kansas.

## **Definition of Terms**

**Core Based Statistical Area (CBSA):** Each CBSA must contain at least one urban area of 10,000 or more population. Each metropolitan statistical area must have at least one urbanized area of 50,000 or more inhabitants. Each micropolitan statistical area must have at least one urban cluster of at least 10,000 but less than 50,000 population. Under the standards, the county (or counties) in which at least 50 percent of the population resides within urban areas of 10,000 or more population, or that contain at least 5,000 people residing within a single urban area of 10,000 or more population, is identified as a "central county" (counties). Additional "outlying counties" are included in the CBSA if they meet specified requirements of commuting to or from the central counties. Counties or equivalent entities form the geographic "building blocks" for metropolitan and micropolitan statistical areas throughout the United States and Puerto Rico (CCD, 2005).

**High school:** A school consisting of grades 9 through 12. Many of the smaller schools in Kansas combine grades 7 and 8 with the high school and one teacher teaches all grade levels. The researcher will include mathematics teachers who teach students in grades 9 through 12. Survey questions, interviews, and observations will be in reference to courses taught in grades 9 through 12.

**High Performing School:** A high school in rural Kansas which has achieved Standard of Excellence in Mathematics two consecutive years in 2003-2005.

**Low Performing School:** A high school in rural Kansas which has had an average of at least 50% of students scoring Basic or below on the Kansas Math Assessment for two consecutive years in 2003-2005.

**Kansas Math Assessment:** A program by the Kansas State Board of Education as mandated by the State Legislature and No Child Left Behind to measure indicators with the Kansas Curricular Standards, provide a building total score to measure Adequate Yearly Progress, report individual student scores, provide scores to be used with local assessment to improve a building or districts' mathematics programs (KSDE, 2006).

**NCTM Standards:** This term refers to the collection of standards documents published by NCTM: *Curriculum and Evaluation Standards for School Mathematics, Principles and Standards for School Mathematics, Professional Standards for Teaching Mathematics, Assessment Standards for School Mathematics*

**Rural:** Any incorporated place, Census designated place or non-place territory not within a Metropolitan CBSA or within a Micropolitan CBSA and defined as rural by the Census Bureau. From 1998–99 onward, the category was separated into “Rural, Inside CBSA” and “Rural, Outside CBSA” (CCD, 2005).

**Rural, inside CBSA:** Any incorporated place, Census designated place, or non-place territory within a Metropolitan CBSA and defined as rural by the Census Bureau. Category represents a subset of “Rural,” and was introduced in 1998–99 (CCD, 2005).

**Rural, outside CBSA:** Any incorporated place, Census designated place, or non-place territory not within a CBSA or CSA and defined as rural by the Census Bureau. Category represents a subset of “Rural,” and was introduced in 1998–99. (CCD, 2005).

**Standards:** Term referring to the collection of NCTM Standards documents: Curriculum and Evaluation Standards for School Mathematics (1989), Professional Standards for Teaching



Mathematics (1991), Assessment Standards for Teaching Mathematics (1995), *Principles and Standards for School Mathematics* (2000)

**Standards-based practices:** Classroom behavior by the teacher that emphasizes problem solving, communication, reasoning, and mathematical connections. Standards-based practices are those in which students use data to justify opinions, experience ambiguity, and work together. The teacher deemphasizes lecture and focuses on active learning through a problem solving approach (Sawada, 2002).

**Standard of Excellence in Mathematics:** In order to achieve Standard of Excellence in grade 10 mathematics in Kansas, the following requirements must be met:

- a. At least 15% of students scoring Exemplary.
- b. No more than 15% of students scoring Unsatisfactory.
- c. It is expected that 40% of students will score Advanced or above.
- d. It is expected that 70% of students will score Proficient or above.
- e. It is expected that 85% of students will score Basic or above.

By using the equation to calculate the building index score:  $[4 \times (\text{percentage of students in Exemplary minus expected percentage of students in Exemplary})] \text{ PLUS } [3 \times (\text{percentage of students in Advanced and above minus expected percentage of students in Advanced and above})] \text{ PLUS } [2 \times (\text{percentage of students in Proficient and above minus expected percentage of students in Proficient and above})] \text{ PLUS } [1 \times (\text{percentage of students in Basic and above minus expected percentage of students in Basic and above})]$  schools who meet 1, 2 and have a building index score greater than 0 will achieve Standard of Excellence in mathematics (KSDE, 2006).

**Artifacts:** Included all assessments, lesson plans, student tasks, assignments and homework related to the unit on functions.

## Summary

The NCTM Standards were developed to improve student learning of mathematics by making the mathematics content more meaningful and accessible to all students. This can only be achieved through consistent and systematic implementation of the Standards by committed mathematics teachers at all levels. The current study looked closely at the practices of high school mathematics teachers in rural Kansas. The next chapter delves more deeply into the purposes, advantages, and disadvantages of implementing the NCTM Standards into the

mathematics classroom. Chapter 3 describes the methodology used in the current study, while chapter 4 and 5 discuss the results and conclusions.

## **CHAPTER 2 - REVIEW OF LITERATURE**

### **Introduction**

The purpose of this study was to determine the extent to which mathematics teachers in high and low performing rural high schools in Kansas demonstrated teaching practices in alignment with the vision of the NCTM Standards. The Standards were designed to make mathematics accessible and meaningful to all students, yet without implementation by classroom teachers, the Standards are ineffective. This chapter will focus on the NCTM Standards, their history and development, the impact of the Standards on teaching practices, the impact of teaching practices on student achievement, and the rural environment.

### ***Principles and Standards for School Mathematics***

#### ***Brief History***

Current reform efforts can be traced back through the past two decades beginning with the report *Agenda for Action* published in 1980 by the National Council of Teachers of Mathematics. The recommendations in this report were a reaction to the Back to Basics movement of the 1970s, data examined from a series of studies funded by the National Science Foundation, and two assessments from the National Assessment of Educational Progress (NAEP). The primary recommendation set forth in *Agenda for Action* was to make problem solving the primary focus of school mathematics. This recommendation also presupposes innovative ways of instruction, implementation of technology, manipulatives as tools for problem solving, cooperative learning, and alternative methods of assessment for all students (NRC, 2001). These recommendations became the foundation for the first draft of *Curriculum and Evaluation Standards for School Mathematics* in 1989 (NCTM, 1989). As the development of the Standards progressed, numerous reports supporting *Agenda for Action* and the need for change in U.S. classrooms became available.

In 1983, the National Commission on Excellence in Education published *A Nation at Risk* stating the quality of math and science education in the United States had been deteriorating.

Focusing on secondary education, the report stated lower expectations, diluted content, and a serious shortage of qualified teachers as some of the reasons for the deficiencies in mathematics education. *A Nation at Risk* recommended three years of mathematics for all high school students with a new demanding curriculum and higher expectations for all students and teachers. These recommendations led individual states to raise high school graduation requirements in math, to improve teacher preparation standards, and increased awareness of teacher shortages in mathematics and science (National Commission on Excellence in Education, 1983).

Following *A Nation at Risk*, in 1989 the National Research Council (NRC) published *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* reporting results from studies conducted to identify weaknesses in the mathematics education system as well as strengths to build on in the future (NRC, 1989). The committee began by examining mathematics education as a whole from kindergarten through graduate study. The results were similar to those found by *A Nation at Risk*: change is needed. Specifically, mathematics educators at all levels must be committed to implementing changes in curriculum appropriate for the twenty-first century, changing methods of instruction and assessment to make mathematics education effective for all Americans, and ultimately improving mathematical achievement (NRC, 1989).

In the early 1980s, The Second International Math and Science Study (SIMSS) assessed the U.S curriculum from an international perspective with similar results. While American students were learning arithmetic in 8th grade and algebra in high school, their Japanese counterparts were learning algebra and calculus respectively. Data collected through Third International Mathematics and Science Study (TIMSS) in 1995 continued to encourage reform in mathematics education with American high school students scoring well below the international average on mathematical literacy. Data was also collected concerning the U.S. mathematics curriculum and teaching practices. The curriculum was determined to be “a mile wide and an inch deep” while classroom practices tended to be significantly different than those of more successful countries. For example, a typical mathematics classroom in the United States tended to begin with questions or review from the previous day’s lesson, followed by the teacher lecturing on new material, and the students finishing class by working homework problems at their desk. In contrast, Japanese classrooms tended to take a mathematical topic, allow students to discover the mathematics collaboratively while gaining a deeper, richer understanding of the

topic (NCES, 2006b). Comparing our classrooms and mathematical success on the international level continued to support and encourage the reform movement towards the NCTM Standards.

In addition, the support given by the National Science Foundation (NSF) and National Assessment of Education Progress (NAEP) reports were influential in shaping the direction of mathematics education for the next decade. Each was instrumental to the 1989 release of *Curriculum and Evaluation Standards for School Mathematics* (1989), and supporting documents: *Professional Standards for Teaching Mathematics* (1991) and *Assessment Standards for School Mathematics* (1995). These three documents were the first attempt by an organization to develop and verbalize specific national goals in mathematics for both teachers and policy makers (NCTM, 2000).

*The Curriculum and Evaluation Standards for School Mathematics* were created to ensure quality, set goals, and promote change by developing a vision of what it means to be mathematically literate in a constantly changing mathematically reliant world (NCTM, 1989). In 1996, the NCTM Board of Directors began the “Standards 2000” project with the purpose of revising and updating the original Standards. *Principles and Standards for School Mathematics* (*Principles and Standards*), released in 2000, was the culminating result of this work. *Principles and Standards* reflects society’s need for mathematical literacy, inclusion of appropriate technology, and presents a set of goals for which mathematics educators should strive to achieve (NCTM, 2000). The NCTM Standards are far more ambitious than traditional programs by raising expectations from routine to higher order application and understanding for all students (Heibert, 1999; Florian, 2001). Each of these standards documents emphasizes the need to build a strong foundation of knowledge (Florian, 2001). By examining the history of the NCTM Standards, we gain a strong foundation for understanding the process and purposes set forth before us by the developers of *Principles and Standards*.

### ***Vision of the Standards***

*Principles and Standards* asks educators to imagine a classroom where all students have access to high quality mathematics instruction. This includes a rich curriculum providing students with opportunities to learn mathematics with understanding. Students will have access to technology and manipulatives, aiding in the solving of complex mathematical tasks to enhance learning. Each mathematics teacher will have the pedagogical content knowledge to assist

students in making connections between previous and new content. Students will value mathematics, work collaboratively to gain mathematical knowledge, and then communicate their findings to others (NCTM, 2000). Students will engage in complex learning that draws on previous knowledge and integrate knowledge from a wide variety of topics. In addition, students will represent mathematics in a variety of ways while developing, refining and testing conjectures based on evidence collected by students. Students will also be able to work productively and effectively alone or in groups and communicate their mathematical ideas to others (Florian, 2001; NCTM, 2000).

Almost all organizations and documents of the reform movement encourage and emphasize such instruction which engage students as active participants in their own learning (McCaffrey et al., 2001). The NCTM Standards set high learning goals that exceed the instructional goals of most U.S. classrooms (Florian, 2001). NCTM developed the Content and Process Standards to be used as a guide for educators to know what is valuable in mathematics education and give direction in making informed decisions that affect school mathematics (NCTM, 2000).

*Principles and Standards* consists of six principles: Equity, Curriculum, Teaching Learning, Assessment and Technology. The first five Standards address mathematical content goals for students in the following specific areas of mathematics: Number And Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability. The five Process Standards are Problem Solving, Reasoning and Proof, Connections, Communication, and Representation which address the processes and skills students should use to apply the mathematical ideas from the Content Standards to school and real world settings. It should be noted that these six principles and ten standards are not disjointed but rather intricately woven together. The Principles provide guidelines that are essential to a high-quality mathematics education. The Standards describe the content needed and the processes students and teachers should use to learn the content (NCTM, 2000).

The Principles provide a guide for educators at all levels to make informed, quality decisions about school mathematics. The Equity Principle promotes high expectations and strong support for all students. The Curriculum Principle emphasizes a curriculum that is coherent, focused on important mathematics, and well articulated across all grades. Requiring teachers to have an understanding of what students know, what students need to learn, and then

providing students appropriate and effective opportunities to learn is at the heart of the Teaching Principle. Learning mathematics with understanding and being able to apply procedures, concepts, and processes with understanding is the premise of the Learning Principle. The Assessment Principle encourages educators to incorporate assessment into the learning process as a method to help students learn. Finally, the Technology Principle recognizes the ever-changing world in which we live. The technology influences what mathematics is taught, how it is taught, and provides opportunities to enhance student learning (NCTM, 2000).

The Process and Content Standards are designed to be a comprehensive foundation for K-12 mathematics education. They provide a basis for the understanding, knowledge, and skills that students should be able to do. It is important to recognize that the Process and Content Standards are not separate entities but rather an intricately woven tapestry to provide the best mathematics education possible. For example, one cannot solve problems without mathematical content knowledge, but mathematical content knowledge can be gained via solving problems (Schroeder & Lester, 1989). The Process Standards should be integrated across all grade levels, but at varying degrees of intensity. Using the Process Standards effectively requires years of practice and nurturing for all students and teachers (Florian, 2001).

In classrooms that are implementing standards-based practices, students should solve real world problems independently and collaboratively, and have access to technology and manipulatives. Students should approach problems from multiple perspectives while using multiple representations, make, refine, explore, and prove conjectures, communicate with each other and the teacher, and reason to justify conclusions. Teachers in a standards-based classroom need to provide opportunities for problem based learning; encourage communication, the use of technology, and manipulatives; use divergent questioning strategies, and assist students in making connections to mathematics content as well as other disciplines (NCTM, 2000).

Effective standards-based instruction emphasizes the development of knowledge and skills in all areas of content and process (Florian, 2001). In 2001, the National Research Council published *Adding It Up*, designed to synthesize the rich and diverse research from PreK-8 mathematics in order to institute a guide to best practices in learning and understanding mathematics. The overarching recommendation of the committee stated that all students need to become mathematically proficient in order to have a deep and useful understanding of

mathematics. The five strands of mathematical proficiency are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

A more indepth look at conceptual understanding from the National Research Council (2001) builds on notions embedded in the NCTM Standards. Students with conceptual understanding know why a mathematical idea is important. By recognizing the context in which the mathematical ideas would be relevant, students can organize concepts into a coherent whole. These facts and ideas learned with understanding help the students remember the material as well as help them connect new ideas to those concepts previously learned. One indication of conceptual understanding is the ability to represent mathematical situations in different ways and recognize that different methods may be appropriate in different situations. This coincides with NCTM's Process Standards of Connections and Representations. Students who can connect mathematical ideas have a longer and deeper understanding of the concepts (NCTM, 2000).

Classroom instruction designed to improve mathematical proficiency requires a change in the roles of both the teacher and the student (Zollman & Mason, 1992). Spillane and Zueli (1999) and McCaffrey et al. (2001) documented that in classrooms where teachers implement standards-based practices, students will be found investigating and working through problem based tasks before formal instruction. Students will collect and analyze data, make conjectures based on findings, use logic and evidence to verify results and justify conclusions. Mathematics makes sense and is meaningful as students work with multiple and various representations of the content. Instruction will include teachers posing meaningful questions that cause students to think divergently. Students working collaboratively and alone while using technology and manipulatives to solidify concepts are integral methods for implementing the vision of the Standards into the mathematics classroom. Teachers will emphasize reasoning over memorization, problem solving over mechanics, make connections between and among mathematical ideas and applications, as well as integrate various formal and informal assessments as part of the learning process (McCaffrey et al, 2001, Spillane & Zeuli, 1999).

NCTM created the Standards documents as a vision for ideal practice necessary for students to gain deep mathematical knowledge beginning with inquiry-based thinking (Tate, 2004). A classroom in which the teacher implements standards-based practices should show evidence of each of the Process Standards while students learn mathematical content. Florian (2001) asserts that to gain the benefits of problem solving, students should be formulating



problems, identifying unknowns, determining the type of answer needed, then justifying their reasoning. Problem solving should begin in kindergarten with students implementing strategies learned at home and continue to grow as the student grows. This does not require the mastery of basic skills before problem solving, but allows the two to interact (Florian, 2001).

### ***Research Related to the Standards***

Mathematics teachers in the United States tend to emphasize computational fluency more than teaching for understanding while failing to challenge students or provide them with the important knowledge for necessary life skills (Florian, 2001; Bush, 2002; TIMMS, 1995). Yet powerful results have been documented by researchers studying classrooms integrating standards-based practices. In a study conducted by Ginsburg-Block and Fantuzzo (1998), low achieving elementary students who were assigned to the treatment groups participated in problem solving and peer collaboration. These students obtained higher scores on mathematics assessments and higher levels of motivation than their counterparts who received neither problem solving nor peer collaboration. Additional studies of those classrooms that integrate problem solving and computation found students' ability to perform computations and procedures did not decrease, and conceptual understanding was enhanced (Carpenter, Fennema, Frandke, Levi, & Empson, 1996; Kilpatrick, Swafford, & Findell, 2001).

Instruction that promotes student understanding through a focus on meaning instead of procedures has been found to increase student achievement (Florian, 2001). Florian (2004) established that teaching for understanding promotes higher student achievement. Implementing opportunities for students to work collaboratively with each other, exploring data, reasoning and justifying results, and utilizing student communication are all methods recommended by the Standards to teach for understanding. Knapp (1995) discovered teaching for understanding in high poverty schools produced increased gains for low achieving students. In addition, teachers' use of a balanced curriculum that focused on developing student conceptual understanding of mathematics as well as procedural skills helped these low achieving students perform above average on state mathematics assessments.

Research has also linked specific instructional practices to increased student achievement. McCaffrey et al. (2001) studied data on tenth-grade students enrolled in traditional or standards-based courses during the 1997-98 academic year. In his effort to determine effects

of curriculum on the relationship between instructional practices and student outcomes, he found that there is some evidence that the use of instruction consistent with standards-based practices in traditional high school algebra and geometry classes is related to higher student achievement using a standards-based curriculum. There was no such evidence when using a traditional curriculum. Riordan and Noyce (2001) compared mathematics achievement from two matched groups of elementary and middle school students in Massachusetts. The fourth and eighth grade students who learned through a standards-based curriculum performed significantly higher on state mathematics assessments than those students not using a standards-based curriculum. Another example of the success of standards-based curriculum was found by Reys, Reys, Lapan, Holliday, and Wasman (2003). Districts using Connected Mathematics Project (CMP) or MathThematics in 8th grade in Missouri for at least two years performed greater than or equal to their matched comparison districts using traditional curriculum on the Missouri state achievement test.

Schoen (2003b) provide extensive research regarding what students are able to do after studying from standards-based mathematics curricula in high school. Scores on Iowa Tests of Educational Development (ITED) were compared for students using Core-Plus Mathematics Project (CPMP) for three years and those exposed to traditional mathematics curriculum. When comparing pre-algebra students and their CPMP matched sample, mean scores for CPMP students were significantly higher on the entire test as well as the Interpreting Information Subtest and Solving Problems Subtest. CPMP students also scored significantly higher on the entire test and Interpreting Information Subtest when compared with Algebra students. Over the three years ITED-Q standard scores for CPMP students consistently increased in rural, urban, and suburban schools (Schoen, 2003b).

Webb (2003) reviewed research on the impact of the Interactive Mathematics Program (IMP) indicating students completing the IMP curriculum were more likely than students in a traditional curriculum to take advanced high school mathematics after completing the three-year school curriculum. Although there were not significant differences on Comprehensive Test of Basic Skills (CTBS) scores between IMP and traditional students, Webb found students who started IMP in grade 9 and who took the SAT, scored significantly higher than those students who started the traditional sequence in grade 9 and took the SAT (Webb, 2003).

In a study using Core Plus Mathematics Project (CPMP), a high school curriculum developed using context along interwoven strands of algebra, geometry, functions, statistics, probability, trigonometry, and discrete mathematics, Schoen (2003a) found certain pedagogical practices employed by the teachers caused the curriculum to be more effective and increased student achievement. These practices included, but were not limited to the following:

- Professional development to teach the new curriculum effectively
- Cooperation with other teachers
- More group and pair work and less teacher presentation
- Minimize non-academic activity
- Implement a variety of assessments

Schoen (2003a) found these to be a partial set of standards-based teaching practices worth pursuing for the high school teacher. There has been little research to determine the effectiveness of these strategies when using a traditional curriculum.

### ***Teachers and the Standards***

Current evidence suggests that teachers are not affected by the Standards and continue to teach in a traditional manner (Manouchehri, 2003). Research has documented if all students are to have the opportunity to master mathematical knowledge; teachers must change what is taught and how it is taught (Spillane & Zueli, 1999; McLaughlin & Talbert, 1993). These changes should then be evident by the tasks a teacher chooses, the role of teachers and students in the classroom discourse, and the classroom learning environment (McCaffrey et al., 2001). It is important to analyze the components of this change in order to determine how to most effectively teach using standards-based practices.

A key feature of *Adding It Up* (NRC, 2001) is the connection made between students attaining mathematical proficiency through teaching for mathematical proficiency. Learning and teaching mathematics is the result of interactions among the content, teachers, and students. “Quality instruction is a function of teachers’ knowledge and use of mathematical content, teachers’ attention to and handling of students, and students’ engagement in and use of mathematical tasks. Effective teaching, which helps develop mathematical proficiency, can take a variety of forms” (p.315). Focusing on the teachers’ knowledge of mathematics, students, and

instructional practices, the same five strands will be used as a guide for effective teaching for mathematical proficiency (NRC, 2001).

Adding it Up (NRC, 2001) describes five strands of mathematical proficiency for teaching including conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Conceptual understanding now includes an integrated knowledge of core mathematics with insight to how students' mathematical understanding develops. Teachers who have high levels of conceptual understanding will be more likely to provide opportunities for problem based learning, as well as model and encourage students to approach problems from multiple perspectives. An important byproduct of conceptual understanding is the ability to help students make connections between old and new content as well as with other disciplines.

A teacher with procedural fluency has developed effective instructional routines, classroom management, and the awareness to change approaches based on students' understanding. Providing numerous and diverse opportunities for students to practice using the various procedures will help students become more comfortable and confident using the procedures. The use of multiple representations and various methods of presentations will assist the students in also achieving procedural fluency.

Strategic competence requires conceptual understanding of core knowledge as well as the ability to adapt the lesson to capture teachable moments. Self reflection through analysis of teaching strategies, student difficulties, and student questions is key to teaching for adaptive reasoning. Assisting students to notice and correct inconsistencies in their own thinking as well as those of their peers are key components of strategic competence and adaptive reasoning.

Finally, the teacher needs to realize that mathematics, understanding of students thought processes, and the teaching practices utilized are all important components of the learning process. Teaching is a process involving a lifetime of learning about students and effective methods to teach the mathematics. A mere label such as standards-based is not sufficient in assisting teachers to achieve this quality instruction. Rather helping educators understand the interaction that takes place between the teachers' knowledge of mathematics, the students, and the students' interaction with the mathematical content as well as each other is critical.

Many of the aforementioned studies target the student achievement related to using comprehensive standards-based curricula. There are very few studies illustrating the connection

between teacher practices aligned with the standards and student achievement. Hiebert (1997) collaborated with researchers from four different projects over five years to determine the best research-based ideas on how to design classrooms to help students learn mathematics with understanding. The following three principles agreed upon by Hiebert and his fellow researchers help educators to comprehend what it means to understand mathematics and what is essential for facilitating students' understanding. First, "understanding can be characterized by the kinds of relationships or connects that are constructed (p. 15)." Second, communication and reflection are key to student's efforts in understanding mathematics. Third, there are five dimensions that function together to create a classroom supportive of students learning mathematics with understanding: the tasks students are asked to complete, the role of the teacher, the social culture of the classroom, the mathematical tools that are available, and student participation in this learning community. This framework can be useful regardless of the instructional approach. In general, Hiebert (1997) found that traditional tasks can be taught more effectively when teachers use standards-based practices.

Remillard (2005), in her review of research on mathematics curriculum use over the last 25 years, finds researchers fail to appreciate the role of the teacher in the classroom. According to Remillard (2005) there is little research on how teachers use curricula or on the teacher-curriculum relationship and the effect this has on student achievement. Teachers must respond to students and possibly unpredictable actions of students when working with the curriculum. Many teachers add or subtract materials from the given curriculum in order to fit their own teaching style and the needs of their students. The mathematics taught in the classroom and learned by the students may be much different than the curriculum adopted by the school, therefore it is important to study the actual teaching practices implemented in the classroom.

As the research connecting teacher practices to student achievement continues, it is important to remember each teacher defines and reports the level of reform in their classroom differently. Spillane and Zeuli (1999) studied the extent to which teachers taught in ways that aligned with state and national standards for mathematics education. They found that different teachers bring different experiences and beliefs into their teaching which results in different courses of action in the classroom. Additionally, some teachers will transform part of their teaching practices while leaving other methods and practices untouched. Although all 25 teachers in the study by Spillane and Zeuli (1999) were very familiar with the NCTM or State

Standards and reported teaching in ways they believed were consistent with the standards, only 4 of the 25 actually taught in a manner consistent with the standards. If these reforms are to be successful, teachers must pay attention to and use the ideas presented in the NCTM Standards concerning mathematics instruction (Spillane & Zueli, 1999).

Integrating standards-based techniques into the classroom requires that the role of the teacher change from the giver of all information to the moderator of student learning experiences (Zollman & Mason, 1992). This change in roles requires that teachers have a deep understanding of mathematical concepts in order to encourage and accurately assess students' understanding (Florian, 2001). Standards-based practices necessitate mathematical knowledge be the primary focus in the classroom which allows students to experience genuine mathematics activity instead of rote drill and practice. Teachers are expected to use tasks that engage students in understanding, but allow students to struggle with the key concepts (Spillane & Zueli, 1999). For this method of learning to be effective, the teacher must have a solid grasp of the key concepts and connections to the mathematical content the students are learning (NCTM, 2000).

### ***Opposition to the NCTM Standards***

As with any reform movement, there are those who strongly oppose the NCTM Standards. Apple (1992) considers the Standards a slogan system with a certain amount of imprecision and ambiguity that allows those who might otherwise disagree to fit under the umbrella, yet specific enough to offer something to educators from time to time. In addition, Apple also finds that the Standards have the ability to charm by offering imaginative possibilities and a call to action without any real direction. Other mathematicians struggle with the dichotomy formed by the traditional curriculum focusing on basic skills, as well as the how of the mathematics, while the reform curriculum attempts to focus on both the how and why of mathematics without doing justice to either one (Wu, 1996, 1997). Ross (2000) voices several concerns about the NCTM Standards including lack of specific expectations and lack of basic skills to concerns about the focus on content and not the pedagogy to teach it.

Wu (1997) argues that although the reform has made mathematics more relevant to the average student, there are at least three major concerns to be considered when implementing the Standards into the classroom: the down-playing of higher order thinking skills, an overemphasis on "real-world applications," and a loss of precision (Wu, 1997). He further argues that

mathematical justifications in reform texts are no longer a valid mathematical proof, but rather a motivational or heuristic argument. While the reform movement prides itself on “higher-order thinking skills” and “mathematical reasoning” many reform texts and documents make bold mathematical assertions without any real justification. This method of explanation not only hinders the development of higher order thinking skills, but primarily targets the average student while doing a disservice to the serious student of mathematics. Mathematically, the traditional curriculum focuses on the how of mathematics, but not the why, while the reform curriculum does just the opposite. What is needed is a curriculum that balances the “how” of mathematics and the “why” behind the process (Wu, 1992, 1996).

Klahr and Nigam (2004) refute the claim that discovery learning, which is a widely heralded method of instruction in the mathematics and science communities, is the best way for students to gain lasting understanding. They argue that most of what students, teachers, and scientists know was taught to them rather than discovered by them. The alleged superiority of discovery learning is inconsistent with much of the literature on learning and memory. Many students in discovery learning situations will be more likely to encounter misleading feedback, encoding errors, and insufficient practice than their counterparts receiving direct instruction.

Finally, Klein (2005) examined math standards in the United State using numerical scores assigned in clarity, content, reasoning, and negative qualities similar to the research completed in Fordham I and II. When assessing the state standards, Klein and his colleagues found nine common major problems among each state’s math standards:

1. Too great an emphasis on calculators.
2. No requirement of memorization of basic facts.
3. No requirement of knowledge of standard algorithms.
4. Lack of attention to coherent development of fractions in late elementary and middle grades.
5. Too much emphasis on patterns.
6. Too much emphasis in manipulatives (especially at higher grade levels).
7. Too much emphasis on estimation.
8. Including probability and statistics too early in the curriculum.
9. No guidelines on how to effectively implement problem solving.

It is important to note that although state standards are not exactly the same as NCTM Standards, many are strongly aligned with the NCTM Standards. Klein recommends including mathematics professors on the committees that write state math standards, emphasizing both computational fluency and conceptual understanding, avoiding the nine problems stated above, and adopt standards similar to those states considered successful such as California, Indiana, or Massachusetts, which scored well on content, clarity, reasoning, and negative qualities on his own analysis of state standards (Klein, 2005).

### ***Summary of Principles and Standards***

As NCTM and others try to improve mathematics education in the United States, there will always be opposition. In many cases it appears that opposition occurs because of misinterpretation of *Principles and Standards* or by taking bits and pieces out of context. *Principles and Standards* is intended to be a resource for all involved in the educational process by arguing for the importance of learning mathematics with understanding. Recommendations of what should be taught and how it should be taught are given throughout; however, it is important to remember these are not mandates. Teachers are given the freedom to integrate methods that work best with their teaching style and their students.

Much opposition comes from misinterpretations and misrepresentation of the standards. For example, Wu (1996) argues that the Standards down-play higher order thinking skills and overemphasize “real-world applications.” In contrast the Teaching Principle suggests real world tasks alone are not sufficient for effective teaching and learning of mathematics. Teachers must decide what aspects of the task to focus upon, how to best organize students, what questions to ask, and how to continually challenge the students to think about the processes on their own (NCTM, 2000). If implemented correctly, the “real-world application” should help to motivate the students and promote higher order thinking.

In order to determine the effectiveness of *Principles and Standards* in the classroom, one must look beyond individual opinions and preferences. A close examination of the teaching practices actually implemented into the mathematics classroom will give a better representation of the impact *Principles and Standards* is making on mathematics students. The researcher will observe classrooms to look for instances of students solving real world problems independently and collaboratively, having access to technology and manipulatives, approaching problems from



multiple perspectives while using multiple representations, making, refining, exploring, and proving conjectures, communicating with each other and the teacher, and reasoning to justify conclusions. The researcher will look for instances of teachers providing opportunities for problem based learning; encouraging communication, the use of technology, and manipulatives; using divergent questioning strategies, and assisting students in making connections to mathematics content as well as other disciplines (NCTM, 2000).

## **Rural Schools**

There is much discussion and difficulty in the educational community as to how “rural” should be defined. The U.S. Census Bureau defines rural populations as those with towns of 2,500 people or fewer, or outside any incorporated place. Previous definitions of rural included those counties that are not metropolitan (metropolitan counties include a city of at least 50,000 and or adjoining counties that have a high urban population) (US Census Bureau, 1995). According to the NCES, which is the definition used in the current study, rural is any place not within a metro or micropolitan core based statistical area (NCES, 2006a). However, it is clear that regardless of the definition that rural communities: are not adjacent to growing urban areas, are experiencing population loss due to the decline in the farming industry, and are able to offer fewer educational and occupational opportunities than their urban counterparts (Kannapel, & DeYoung, 1999).

Nearly one third of America’s children attend public schools in rural areas or small towns (Beeson & Strange, 2003). One fourth of the nation’s population lives in rural areas including over six million people below the poverty level (Shultz, 2003). Twenty percent of all mathematics lessons are taught in a rural/small town (Silver & Castro, 2002). Rural education should be a key focus for advocates of American education; yet rural areas have largely been ignored by national movements in mathematics education (Bush, 2002). Rural education, the rural environment, and the people who are members of rural communities are important and should be given more consideration (Beeson & Strange, 2003). Lee (2000) contends rural education provides a barometer for monitoring national progress in public education. With such a large percentage of the population growing up and being educated in a rural environment, it is critical that rural education is understood and studied in order to improve student success in the mathematics classroom.

Rural schools have some similarities with their urban counterparts, but in many ways the two educational environments are vastly different. The work of Howley (2001) indicates the members of rural communities tend to value place, community, and family over larger national issues. Rural families tend to embrace more traditional values such as the family unit, discipline, and hard work. Many members of rural communities will choose lower paying jobs in order to stay closer to family and the rural way of life. The schools tend to be the cultural center of the community providing entertainment and a sense of purpose as well as supporting a greater percentage of students involved in extra-curricular activities. Community members tend to care more about respectable kids, good athletic teams, and strong community ties over the specific elements of the educational curriculum including mathematics. Many rural students and their parents are often torn by the expectations to leave the rural environment that higher education affords. Attention to these rural issues, ways of life, cultures and political economics is important, and should influence the educational processes implemented in these rural locations (Howley, 2001; Kannapel & DeYoung, 1999).

Rural and urban schools share other differences as well. Small, rural schools tend to have a lower percentage of minority students and a higher percentage of students in poverty than their urban counterparts. In 2002-2004, nearly 80% of all students in rural schools were considered white or non-Hispanic while non-rural schools average 56% white or non Hispanic students (NCES, 2006a). Almost forty percent of the poor live in urban areas, but more than one in five persons living in poverty in the United States lives in rural areas (Dalaker, 1999). In addition, rural educators tend to be younger, less experienced, receive less professional preparation, teach more classes, and are paid less than urban educators (Kannapel & DeYoung, 1999).

Silver and Castro (2002) found it is typically more costly to provide equal educational opportunities in rural locations. Rural schools tend to lack facilities, course offerings, and educational opportunities that can be provided in more resource-rich districts. Many times it is not feasible to offer advanced courses because there are not enough students to justify offering such courses (Silver & Castro, 2002). Transportation costs are another concern that urban schools do not have to consider. In Kansas, rural schools spend 4.5% of their money on transportation (Beeson & Strange, 2003).

Difficulties in recruiting and retaining highly qualified teachers are additional issues rural schools must face (Schultz, 2000; Lee, 2003). While teacher quality is one of the most important

factors in students' learning of mathematics, rural schools have difficulty competing for high quality teachers because of low pay, professional and social isolation, and lack of community services including health care (Arnold, 2003; Murphy & Angelski 1997). Research supports the concept that rural mathematics teachers need to have qualities of highly effective teachers (deep knowledge of the subject matter, flexibility, the ability to encourage all students to learn, use a problem solving approach etc.) as well as an appreciation of the rural community and school-community relations (Sutton & Krueger, 2002). The ability and willingness to coach a sport or sponsor other extra-curricular activities is also highly desirable for rural educators (Arnold, 2003).

Traditional arguments suggest small schools are less efficient than larger schools implying that mathematics education in rural schools needs to be improved (Haller, 1993; Howley, 2003). Shultz (2002) found the performance of urban students was consistently better on NAEP tests than students from rural and small towns. Across twenty-five years of NAEP testing there is little change in the mathematics performance of rural schools. Yet, the performance of rural schools only differs slightly from the national average (Howley & Gunn, 2003). These lower scores on national assessments are thought to be caused by disadvantaged curricular/instructional conditions and potentially low teacher quality (Howley & Gunn, 2003).

Yet many other studies have documented different results concerning rural schools. According to Haller (1993), studies show students in small schools are at least as successful as their counterparts in larger institutions. In 2003, Howley and Gunn found that the rural versus non-rural achievement gap does not exist. Rural assessment scores have risen in the last decade more than those of non-rural assessment scores with rural students outperforming non-rural students in mathematics achievement on NAEP tests in 1996 (Lee, 1996).

Rural schools also offer many advantages. The more intimate environment of small schools increases student engagement which improves student achievement (Overbay, 2003). Rural schools often offer a supportive environment which offsets the negative aspects of the rural environment (Lee, 2003). Smaller schools may have a positive impact on student achievement which may be important for improving education of an at-risk population (Overbay, 2003). In many ways rural schools are no longer different from urban schools, however, teachers may believe those students in rural areas are less able and less likely to achieve excellence. In

addition, they may feel the same about their own professional growth and abilities which may result in lower achievement of both teachers and students (Schultz, 2002).

### **Summary**

There is research supporting the implementation of the NCTM Standards as well as a contingent of people opposed to the Standards. The impact of these Standards on any one particular school and any one particular group of students can only be determined by the level of implementation of the Standards by the teacher. Chapter 3 will introduce the methodology used to study the extent to which teachers implement practices aligned with the NCTM Standards in low and high performing rural high schools in Kansas followed by results and conclusions in the final two chapters.

## **CHAPTER 3 - Methodology**

### **Overview**

The NCTM Standards were developed to make mathematics accessible and meaningful to all students; however, the Standards cannot be effective if teachers do not embrace the ideals and implement the practices aligned with the Standards. The purpose of this study was to determine to what extent teachers in rural high schools were implementing standards-based practices in the mathematics classroom by examining behaviors of high school mathematics teachers. The following questions provided the specific foci of the study:

1. To what extent do teachers in high performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
2. To what extent do teachers in high performing rural high schools implement teaching practices aligned with the NCTM Algebra Content Standards?
3. To what extent do teachers in low performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
4. To what extent do teachers in low performing rural high schools implement teaching practices aligned with the NCTM Algebra Content Standards?

### **Research Design**

This two-phase study was a mixed design using both quantitative and qualitative data from four main sources: survey, interview, observation, and collection of artifacts. Phase I of the study involved surveying all mathematics teachers in high performing (those schools achieving Standard of Excellence in mathematics during 2003-2005) and low performing (those schools with at least 50% of students scoring at Basic or below on the state mathematics assessment during 2003-2005) rural high schools throughout the state of Kansas. Data collected in Phase I were used to examine differences and similarities in teaching practices of teachers from high and low performing schools. The Kansas State Department of Education (KSDE) website along with data collected in the survey was used to create a smaller set of four matched pairs for interviews, observations, and collection of teacher work samples throughout Phase II. Data collected in

Phase II were analyzed to further explore any existing patterns among high performing and low performing schools. Results from teachers in high and low performing schools were compared and contrasted to determine if there were differences between the teaching practices that were demonstrated by each group of teachers.

During Phase I, a survey to measure demographic characteristics and perceived classroom practices was sent to each high school mathematics teacher in 124 rural high schools in Kansas. These high schools represent all high performing and low performing schools during the 2003-2004 and 2004-2005 school years. Approximately one third of these rural districts were considered high performing while the remaining two thirds of the districts were considered low performing. All were surveyed in order to maximize the opportunity to select eight matched schools for Phase II of the study. Thirty-eight percent of teachers responded from each category, 23 of the 61 teachers from high performing schools and 54 of the 141 teachers from low performing schools. High performing schools were matched with low performing schools based on demographic data from the survey in questions 1-5 as well as data from the Kansas Department of Education: percentage of economically disadvantaged students, limited English proficiency, and migrant students. Each pair had as many characteristics identical as possible except one was high performing and the other low performing to eliminate bias from variables such as SES, LEP, and migrant students.

Phase II of the study allowed the researcher to gain indepth information from the smaller sample of four matched pairs by interviewing, observing, and analyzing teacher work samples all based on a unit covering functions. The original plan was to study five matched pairs of schools. Due to the low response rate from the surveys only four could be found. Each principal and high school teacher was contacted and permission was gained to interview and observe. One teacher from each matched school was willing to participate in Phase II of the study. Each teacher was interviewed during the first stage of Phase II to gain a more thorough understanding of the implementation of standards-based practices in his/her classrooms. Functions were used as the mathematical content focus for interviews and observations. In the second stage of Phase II, the researcher observed the same teacher in each school to determine how the Process and Content Standards were being implemented into the classroom. Process standards included Problem Solving, Reasoning and Proof, Communication, Connections, and Representations while Content Standards were the Algebra components of *Principles and Standards* which are understand

patterns, relations, and functions, represent and analyze mathematical situations and structures using algebraic symbols, use models to represent and understand quantitative relationships, and analyze change in various contexts. More specifically, the researcher was looking at how teachers implement and use manipulatives, technology, cooperative learning, problem-solving, investigations, classroom discourse, and various assessment strategies. In addition the researcher examined the interaction between students and the classroom teacher and other students to determine if students were given opportunities to explore and investigate data, make conjectures, and explain and justify their reasoning and conclusions. The third stage of Phase II included collecting teacher work samples taken from the functions unit, including lesson plans, student tasks, assessments, and assignments which were used to gain an in-depth look at teacher practices related to the mathematical content. Analysis of these data revealed observed behaviors of rural high school teachers concerning standards-based practice; possible relationships between teacher behaviors concerning standards-based practices and success on state mathematics assessments; and similarities or differences between high performing and low performing schools.

### **The Setting**

This study was conducted in rural high schools in Kansas. There were approximately 365 high schools in Kansas enrolling between 26 and 2,300 students. As of fall 2005 there were more than 143,000 students enrolled in grades 9-12 (KSDE, 2005). According to the KSDE website 11.17% of all students in Kansas are Hispanic, 8.48% are African American, and 74.45% are white. In addition, 38.25% of students in Kansas are considered economically disadvantaged. Nearly 49% of all students and 80% of all high schools in Kansas are considered rural (NCES, 2006a).

For the purpose of this study, rural schools were classified as those designated by the National Center for Educational Statistics (NCES) as Rural Outside Core Based Statistical Area (CBSA). Rural is defined as “any incorporated place, Census designated place, or non-place territory not within a Metropolitan or Micropolitan Core Based Statistical Area containing a population of 10,000 or more” (NCES, 2006a). As identified by NCES, there were 180 rural schools in Kansas. Thirty of these rural schools met the Standard of Excellence in math during the 2003-2004 and 2004-2005 school year and were defined as high performing for the current

study (NCES, 2006a; KSDE, 2006). Of the 180 rural schools, 65 of these had more than 50% of their students scoring Basic or Unsatisfactory on the state assessment during 2003-2005 school years and were considered low performing for the current study (KSDE, 2006).

The four pairs of schools were chosen and matched based on results from the survey and information taken from the KSDE website. The school report card on the KSDE website was used to initially match high and low performing schools based on the following six characteristics: public or private, grade levels, size of grades, students eligible for free and reduced lunch (within 10%), percentage of minority students (within 10%), and percentage of students with limited English proficiency (within 10%) (KSDE, 2006). Data from the survey including years of teaching experience and willingness to participate in Phase II were then used to better align the matched pairs. Interviews, observation, and work samples were focused on a functions unit in Algebra I and Algebra II classrooms of each matched school during the first unit on functions during the fall semester of 2006.

### **The Participants**

The participants in the study were rural high school mathematics teachers in Kansas. All high school teachers from high performing and low performing schools during the 2003-2005 school years were surveyed in Phase I of the study. Four pairs of high schools were then matched for Phase II of the study. All high school teachers purposefully selected for Phase II were interviewed, observed, and artifacts were collected relating to a unit on functions in an algebra class.

**Table 3.1: Demographic Comparison of School A and B**

	Teacher A – High Performing School	Teacher B – Low Performing School
Location	Southwest Kansas	Southwest Kansas
Student Population	94% White 3% Hispanic	92.7% White 5.06% Hispanic
Economically Disadvantaged Students	30%	21.9%
Limited English Proficiency	7%	0%
Students with a Disability	12%	11.8%



Teacher A, from a high performing school, and Teacher B, from a low performing school, were the first matched pair. Demographic data taken from the 2004-2005 School Report Card is reported in Table 3.1. Both schools were located in southwest Kansas. The student population of each district was approximately 93% white with less than 30% of students considered economically disadvantaged. Seven percent of the students in District A had Limited English Proficiency (LEP) while District B reported no LEP students. Each school reported approximately 12% of their students had a disability (KSDE, 2006).

**Table 3.2: Comparison of Characteristics of Teacher A and B**

	Teacher A	Teacher B
Initial Training Received	1990s	1990s
Experience	6-14 years	6-14 years
Math Education Training	Master's with specialty in mathematics education	Initial degree
Course Load	6 different classes	2 at time of interview 5 at time of test results
Number of Students	11-15 students	11-15 students
NCTM Standards	Very familiar, read them	Aware of Standards

Teacher A received her initial teacher training in the 1990s from a university in Kansas. She had been teaching between 6 and 14 years at a small school district in southwestern Kansas. Recently, she received her Master's degree with a specialty in mathematics education. As can be evidenced in Table 3.2, she taught six different subjects per day with between 11 and 15 students in each class. She was assuming the extra-curricular responsibilities of forensics coach during the time of the study. Teacher A, from a high performing school, stated that she has read the NCTM *Principles and Standards* and was very familiar with their purpose.

Teacher B was slightly older than Teacher A but also received her initial teacher training in the 1990s at a university in Kansas. She had spent an equal amount of time (between six and fourteen years) at a small school district in southwestern Kansas. The extent of her formal college training in the teaching of mathematics was what she received from her initial teacher training program; however, she was working towards her master's degree in counseling. At the

time of the interview, she taught two mathematics classes per day and spent the remainder of the day performing counseling duties. During the 2003-2005 school years, she was the primary mathematics teacher at her school. Teacher B, from a low performing school, stated that she was aware of the NCTM *Principles and Standards* but had not read them.

**Table 3.3: Demographic Comparison of School C and D**

	Teacher C – High Performing School	Teacher D – Low Performing School
Location	Northwest Kansas	Northwest Kansas
Student Population	98.6% White	97%
Economically Disadvantaged Students	37.8%	37.9%
Limited English Proficiency	0%	0%
Students with a Disability	14.7%	13.8%

Demographic data for the second matched pair of teachers, C and D, is compared in Table 3.3. Each school reported approximately 97% of their students were white with no LEP or migrant students. Both schools reported nearly 38% of students were considered economically disadvantaged. Approximately 14% of students were considered to have a disability (KSDE, 2006).

**Table 3.4: Comparison of Characteristics of Teacher C and D**

	Teacher C – High Performing	Teacher D – Low Performing
Initial Training Received	1970s	1960s
Experience	25+	25+
Math Education Training	Initial Degree	Master’s with specialty in Mathematics Education
Course Load	4 classes per day	4 classes per day
Number of Students	<10	11-20
NCTM Standards	Aware	Had read them

Teacher C, from a high performing school, had taught at the school district for more than twenty-five years after completing his initial training in the seventies from a university in

Kansas. He had taken no mathematics education courses beyond that of his initial degree. He taught four classes per day with ten or fewer students while sponsoring extra-curricular activities. Teacher C stated that he was aware of the NCTM *Principles and Standards* but didn't know very much about them.

Teacher D, from a low performing school, had been teaching at the high school for more than twenty-five years after completing his initial training in the sixties from a university in Kansas. Throughout his tenure, he earned a graduate degree with a major or specialty in mathematics education. He was responsible for teaching between eleven and twenty students in each of his four classes per day as well as supporting students in extra-curricular activities. Teacher D stated that he is aware of and had read the NCTM *Principles and Standards*.

**Table 3.5: Demographic Comparison of School E and F**

	Teacher E – High Performing School	Teacher F – Low Performing School
Location	South Central Kansas	Western Kansas
Student Population	94.2% White	86.8% White 4.7% Hispanic
Economically Disadvantaged Students	27.1%	32.1%
Limited English Proficiency	0%	3.8%
Students with a Disability	10.7%	4.7%

The third match consisted of schools E and F. School E was located in a more populated area of rural central Kansas with twice the enrollment of School F, located in rural western Kansas. Both reported between 11-15 students in their mathematics classes. Each school reported less than 4% of the student population was considered LEP with no migrant students. Comparisons of percentages of economically disadvantaged students and student population can be found in Table 3.5.

Teacher E, from a high performing school, received her training in the 1990s from a university in Kansas. She had been teaching at the current school district for five years with no formal training in mathematics education beyond her initial courses. Between eleven and fifteen students attended each of her six classes per day. Teacher E only had three different

preparations for these six classes and was also involved in sponsoring extra-curricular activities for the students. There were three other mathematics teachers at her school. Teacher E reported she was aware of the NCTM *Principles and Standards* but had not read them.

**Table 3.6: Comparison of Characteristics of Teacher E and F**

	Teacher E – High Performing School	Teacher F – Low Performing School
Initial Training Received	1990s	1990s
Experience	5 years	6-14 years
Math Education Training	Initial Degree	Initial Degree
Course Load	3 different courses	6 different classes
Number of Students	11-15 students	11-15 students
NCTM Standards	Aware but had not read	Aware but had not read

Teacher F, from a low performing school, had also been teaching at her current school for the past five years; however she had more teaching experience than teacher E. She had completed no training in mathematics education beyond her initial degree which was completed in the nineties at a university in Kansas. Teacher F taught six different classes per day with 11-15 students attending. She was also aware of the NCTM *Principles and Standards* but had not read them.

**Table 3.7: Demographic Comparison of School G and H**

	Teacher G – High Performing School	Teacher H – Low Performing School
Location	Northwest Kansas	Southwest Kansas
Student Population	98.9% White	84.9% White 14% Hispanic
Economically Disadvantaged Students	47.8%	44.7%
Limited English Proficiency	0%	6.7%
Students with a Disability	22.8%	10.6%

The final set of matched schools was also separated by distance. Demographic data taken from the 2004-2005 School Report Card is reported in Table 3.7. School G, a high performing school, was located in northwestern Kansas while School H, a low performing school, was in southwestern Kansas. Both schools were located in very rural areas. While both schools had nearly 50% of all students considered economically disadvantaged, School G had no LEP or migrant students compared to School H which had nearly 7% and 10% of students in the respective categories. Twenty-two percent of students at School G had some disability which was nearly double that of School H. The student population at School G was 98% white compared to 85% at School H with 14% of the students considered Hispanic.

**Table 3.8: Comparison of Characteristics of Teacher G and H**

	Teacher G – High Performing School	Teacher H – Low Performing School
Initial Training Received	1990s	1980s
Experience	10 years	6-14 years
Math Education Training	Initial degree	Initial degree
Course Load	5 math classes 2 German classes	4 math classes 1 chemistry class
Number of Students	11-15 students	21-25 students
NCTM Standards	Read	Aware

Teacher G, from a high performing school, had taught at the present school for the past ten years after completing his training from a university in Kansas in the nineties. He had completed some additional coursework in mathematics education but had not completed a second degree. Throughout the school day he taught five mathematics classes and two German classes with between eleven and fifteen students in attendance. Teacher G stated that he had read the NCTM *Principles and Standards*.

Teacher H, from a low performing school, completed her training in the eighties but had been teaching in the current school district approximately ten years. Her only formal college training in math education came from her initial degree program. Throughout the day she taught four math classes and one chemistry class with 21-25 students in attendance. Teacher H stated that she was aware of the NCTM *Principles and Standards* but did not know much about them.

## **Data Collection**

### ***PHASE I***

#### ***The Survey Instrument***

Each high school mathematics teacher from the 124 high and low performing schools received a letter explaining the purpose and goals of the study as well as inviting them to participate in the study. A letter explaining the study including consent forms (Appendix A), and the survey to determine perceived classroom practices related to the NCTM *Principles and Standards* (Appendix B), was mailed to the participants in May 2006. Throughout the entire study, each individual's responses were kept confidential from outside sources. The researcher was the only person to link data back to the individual teachers or individual schools and districts.

The survey focused on background knowledge and implementation of the standards. Questions for the survey were taken from a survey created and modified by Horizon Research for McCaffrey et al's work "Interactions among Practices, Curriculum, and Achievement" (2001). The questions from the initial survey were unmodified from the 2001 study and left completely intact for the current study. However, five questions (18, 22, 25, 34, 39) were added to the survey to meet the needs of the current study.

Questions 1-12 were to determine demographic information. The next twenty-seven questions (13-39) focused directly on classroom practices of each individual teacher and the students in the classroom. Questions 13-32 were used to determine student and teacher behaviors according to instruction and assessment practices aligned with the reform movement (student-led discussions, investigations, problem-solving, and alternative assessment strategies). The next four questions (33-39) were aligned with more traditional based practices. Each question was based on a five-point Likert scale: 1-Never, 2-Rarely (once or twice a year), 3-Sometimes (once or twice a month), 4-Often (once or twice per week) and 5-Almost Daily.

Questions 13-39, except 18, 22, 25, 34, and 39, were validated by HRI using classroom observations, teacher interviews, and examination of artifacts. A trained validator from HRI

made a decision concerning the degree each teacher's instructional practice in the classroom reflected reform practices. These ratings were then compared with the surveys completed by the classroom teachers. HRI's analysis showed a moderately high correspondence between survey responses and data collected from more qualitative methods with a Spearman-Rho correlation coefficient of 0.44 (Klein, 2000). Further information on construct validity and reliability will be described under the section Instrument Validity.

Survey questions concerning classroom practices (13-39) were sorted into six categories: problem solving, reasoning, communication, connections, representations, and traditional practices. These six categories were used for statistical analysis to examine how teachers were implementing the Standards into the mathematics classroom. The sums of individual responses were calculated to determine values for each of the six categories. Questions 15, 19, 21, 23, 24, and 34 were used to assess problem solving in the classroom. Questions 16 and 30 were used to assess reasoning. The Communication Principle was assessed using questions 13, 16, 21, 23, 26, and 33. Questions 15, 24, and 25 were used to assess Connections. Representations were assessed using questions 14, 18, 20, and 22. Finally, traditional practices were assessed using questions 33, 35, 36, 37, 38, and 39. Data from these six categories were then compared with data from four demographic questions: when teachers received their initial degree, the number of years of teaching experience, extent of formal college training in mathematics education, and awareness of the NCTM *Principles and Standards*. These data were analyzed to examine similarities and differences in rural teachers' teaching practices in high and low performing schools. By comparing levels of training and knowledge of the *Principles and Standards* against perceived classroom practices, a better understanding of teacher's classroom behavior in high and low performing schools, as well as an understanding of underlying beliefs can be attained.

Question 40 was open ended, asking teachers for any additional information they would like to share concerning implementation of standards-based practices in their classes. In addition, teachers were asked if they were willing to participate in Phase II of the study.

## ***PHASE II***

### ***The Interview Protocol***

After the surveys were returned and analyzed, four pairs of schools were selected for the interview and observation process of the study. Interview questions were used as a method of

probing more deeply into the practices of each teacher through informal discussion concerning items from the survey as well as the observed lessons. Each interview was audio-taped, transcribed, and then coded to look for themes and patterns within the interviews.

The interview questions (Appendix C) were developed by the researcher from the survey instrument with the intention of gaining a deeper understanding of each teacher's implementation of the NCTM *Principles and Standards*. Question 1 was designed to examine how curriculum decisions were made in the district which may effect what practices are implemented in the classroom. Question 2 asked teachers to describe a typical day in the classroom which correlates with the Process Standards and with questions 13-39 of the survey concerning classroom practices. Question 3 was designed to gain a deeper understanding of the typical classroom behaviors of each teacher concerning the Process Standards. By probing teachers regarding their approach to a new topic, the researcher hoped to determine the behaviors that were deemed most important with respect to the NCTM Process Standards. Questions 4 and 5 of the interview addressed teachers' assessment practices corresponding to questions 29-32 and 38-39 of the survey. Questions 6 and 7 of the interview explored factors that may attribute to and/or hinder student's success in mathematics. These questions gave the researcher a glimpse into the learning environment at the school.

### ***Observation Protocol***

During the fall 2006 semester, each high school mathematics teacher participating in the study at the eight selected schools was observed and videotaped twice during the first unit covering functions. The researcher met briefly with the teacher for a post-lesson interview to allow the teacher to discuss the lesson and provide any additional information. Data collected from each observation was kept confidential from outside sources as the researcher was the only person to link data back to the individual teachers, schools, or districts. Observations focusing on instructional practices and standards-based teaching were completed after, but not necessarily immediately following, the interview.

The researcher developed the observation protocol to triangulate the observation data with the survey and interview data. The observation protocol (see Appendix E) was created to focus on the teacher's implementation of standards-based practices. Tables 3.9, 3.10, and 3.11 include an extensive list of specific behaviors attached a standards-based classroom and the



Process Standards. These behaviors can be evidenced through students working to solve real world problems independently and collaboratively through the use of technology and manipulatives. Teachers model and encourage students to approach and solve problems from multiple perspectives while using multiple representations. Students make, refine, explore, and prove conjectures throughout the learning processes. Finally, as active participants in the learning process students should justify their conclusions as well as communicate their methods and solutions to others (NCTM, 1989, 1995, 2000).

The observation protocol is separated into three parts: background information, contextual background and activities, and the lesson. Information concerning the teacher, school, lesson, and subject were recorded under background information. The researcher also made contact with each teacher before formal observation to determine the topic and goals of the lesson.

Part II of the observation protocol was contextual background and activities. Observing the teacher and students in their natural environment provided the researcher valuable information. A brief description of the classroom environment included but was not limited to: space, seating arrangements, availability of technology and manipulatives, bulletin boards, etc. The physical presence of a classroom can have a positive or negative affect on the development of the mathematical learning community. According to the *Principles and Standards*, it is important for the teacher to provide opportunities for the students to interact with each other and the content (NCTM, 2000). In addition, any relevant details about the students including number, grade level, gender, and ethnicity were recorded here. By observing the display of problem solving models, noting the technology that was available for the students, and viewing the arrangement of the classroom, the researcher was able to gain a better understanding of the level at which standards-based practices were implemented.

The observation of the lesson was the most critical and detailed part of the observation protocol. It has become more evident that curriculum does not stand alone as instruction; therefore, interactions among the student, teacher and content must be addressed. Student and content interactions were observed to determine evidence of student understanding, possible misconceptions, the learning community, and how the teacher and learner reflect on their learning process. Through conversations, presentations, and student work, the researcher looked for evidence that students understood the key concepts. Teacher and content interactions were

observed to determine how the teacher approached the content and the methods used to communicate this content to the students. The various learning opportunities presented to the students such as: routine and non-routine tasks, memorization of rules, linking to previous knowledge, investigating, or drill and practice, were used to determine the level of implementation of standards-based practices in the classroom. Finally, student and teacher interactions were observed to determine the use of communication, the type of learning community that had developed, and who was the keeper of knowledge in the classroom.

### *Artifacts*

Each teacher submitted the following artifacts: assessments, assignments, student tasks, and lesson plans for the unit on functions. By analyzing the content assessed informally via assignments or formally via exams, the researcher was able to examine the content valued by the classroom teacher. Examination of lesson plans completed by the teacher allowed the researcher a glimpse of classroom dynamics and to gain perspective from the viewpoint of the classroom teacher.

Worksheets and tests were examined to determine the types of problems students were expected to solve. The problems were sorted into two categories which were not necessarily mutually exclusive: symbolic manipulation and understanding. Those questions that required students to solve or write an equation without any meaning or understanding were considered strictly symbolic manipulation. In contrast, those questions requiring students to explain an answer, process, or concept were considered “understanding” questions. *Principles and Standards* advocate learning mathematical skills with meaning. The artifacts were also examined to determine the types of representations students were required to use. Multiple representations included tables, functions, verbal, graph, mappings, technology, and real world examples. Word problems were also examined to determine the level of sophistication and processes necessary for the students to arrive at a solution. In many cases the word problems were considered symbolic manipulation problems instead of “understanding” problems. Questions from worksheets and tests were also compared to the NCTM Process and Content Standards.

Lesson plans, textbooks, and activities were also examined to determine the use of the standards in planning. The researcher was specifically looking for the use of non-routine

problems, problem solving before formal lecture; problem based lessons, and extended mathematical investigations. These processes encourage students to learn the mathematical concepts with understanding and meaning as suggested in *Principles and Standards*.

## **Data Analysis**

### ***PHASE I***

#### ***Survey Analysis***

This survey was designed to give the researcher general background information such as education, number of years teaching, textbook used, class size, teaching load, and class length. Those data were summarized by calculating means, medians, mode, standard deviation, range, and percentages. Data collected from Section I of the survey provided demographic data for each teacher. Those data were used to compare the characteristics of teachers in high and low performing rural schools in Kansas. In addition, those data were used to select the four pairs of school districts for the interview and observations of teachers.

The responses to Section II concerning classroom practices were interpreted through the calculation of percentages each question as well as levels within each category of questions. This method provided results about teachers' classroom practices concerning the NCTM *Principles and Standards*. Questions 13-39 were then sorted into categories based on six categories, the five principles presented in *Principles and Standards*: problem solving, reasoning, communication, connections, representations and one additional category labeled traditional practices. Questions 15, 19, 21, 23, 24, and 34 were used to assess Problem Solving in the classroom. Questions 16 and 30 were used to assess Reasoning. The Communication Standard was assessed using questions 13, 16, 21, 23, 26, and 33. Questions 15, 24, and 25 were used to assess Connections. Representations were assessed using questions 14, 18, 20, and 22. Finally, traditional practices were assessed using questions 33, 35, 36, 37, 38, and 39. The sum of the survey results in each category was calculated to determine the value assigned to each category. Results for each of the six new categories were compared to four pieces of demographic data which included when initial training was completed, years of experience, extent of formal training in mathematics education, and knowledge of the standards. These data

were analyzed to examine similarities and differences in rural teachers' teaching practices in high and low performing schools concerning the *Principles and Standards*.

## ***PHASE II***

### ***Survey Analysis***

Survey results were compared for each of the matched pairs to determine any differences and/or similarities that may occur between the two high schools and the two teachers. Responses to the first six questions should be very similar as that is how the matches were chosen. Average times spent on standards-based and traditional practices were calculated and compared across matches. Individual survey responses were compared to data gathered from interviews and observations in order to triangulate data.

### ***Interview Analysis***

Each teacher from the purposefully selected matched high schools was interviewed regarding typical classroom practices. Each interview was tape-recorded and the researcher took notes during and after the interview. Recordings were transcribed and included with the researcher's notes. Interviews were coded based on teachers' references to problem solving, problem based learning, students use of reasoning and justification, communication, connections, and various representations including technology that are encouraged throughout *Principles and Standards*.

Question 1 corresponded to questions 13-34 of the survey by asking how curriculum decisions are made in the district. The researcher probed deeper into the districts' standards and the driving force for curriculum decisions. Districts and teachers who are focused on the textbook may not be concerned about the ideals and practices recommended in *Principles and Standards*. The second interview question asked teachers to describe a typical day in the classroom correlating with questions 13-39 of the survey concerning classroom practices. Teachers who are implementing standards-based practices into the classroom will be more likely to talk about problem solving, students making connections, and justifying reasoning and results. A traditional classroom will involve more teacher lecture and students working on homework problems. By asking the teacher this question before the observation, the researcher gained insight into how the teacher perceives his/her classroom.

Question 3 was designed to gain a deeper understanding of the teachers' approaches to the Process Standards. By probing teachers regarding their approach to a new topic, the researcher hoped to determine the classroom practices that are most important to the teachers with respect to the NCTM Process Standards. Once again, the researcher was looking for evidence of students making connections, the use of multiple representations, and students solving problems alone and collaboratively. Questions 4 and 5 of the interview addressed teachers' assessment practices which corresponded to questions 29-32 and 38-39 of the survey. Informal and varied assessments are a key element of the standards-based classroom. Divergent thinking and thought provoking questions would be posed to students for them to be active participants in the learning process. The next interview question explored factors that may contribute to and/or hinder student's success in mathematics. By using a variety of questions, the researcher hoped to learn more about the culture at the school, the implementation of standards-based practices in the mathematics classroom, as well as become aware of the many factors that contribute to students' success in the rural mathematics classroom.

### ***Observation Analysis***

An observation protocol was followed, lessons were video taped and transcribed, and field notes were taken concerning teaching practices in the classroom. Data gathered from the observations added insight to the responses gathered through surveys and interviews. Once again this allowed for triangulation of data. Comparisons and contrasts were drawn from the teachers' perceived implementation of NCTM *Principles and Standards* and those observed in the classroom.

The data collected from observations was evaluated by comparing the classroom practices of those teachers in both high and low performing schools. Observational data was compared with data collected from the survey and interviews to determine possible relationships between teachers' behavior in the classroom and student achievement on state assessments for both high and low performing schools.

For example, a standards-based lesson might begin by acknowledging students' previous knowledge and then moving into investigation or problem solving before beginning more formal explanation. Student ideas are critical in determining the direction of the lesson while the teacher supports and encourages alternate solution strategies. Content is a critical piece of any

lesson, but a standards-based approach advocates that students gain coherent understanding across mathematical topics as well as across other disciplines. Students are also encouraged, through the Standards, to use abstraction when appropriate.

### *Artifact Analysis*

The use of carefully designed student tasks and assessment tools have the potential to produce a powerful influence in promoting student's critical thinking and understanding within the mathematics curriculum. Standard-based mathematics tasks would encourage students to develop mathematical understanding through communication, problem solving, and mathematical reasoning (NCTM, 1991).

Tasks were analyzed based on the following criteria:

- accessibility as well as challenging to all students
- connection to other knowledge in other areas to connect the overall body of knowledge
- require multiple representations and processes that encourage higher-order thinking skills
- potential for communication, representation, and construction of ideas
- provide the teacher insight to determine the next instructional step

Tools used for assessing students' knowledge of mathematics were also examined to determine the content rural teachers deem important. Assessment is not a new idea for teachers as they should constantly check students' understanding through informal questioning or more formal exams. It is imperative that assessment is part of the learning process. NCTM (1995) states that assessment should reflect the mathematics that all students need to know by having students solve problems that require both procedural and conceptual knowledge. In addition, assessment should be used to monitor progress, make instructional decisions, and evaluate students' progress (Florian, 2001). Assessment tools were compared and contrasted with the survey, observation, and interview results.

Assessments were coded and analyzed based on the following criteria:

- students required to carry out procedures with understanding and meaning
- students required to comprehend concepts, operations, and relations
- students required to make connections with other mathematics or other disciplines

- reflection, explanations, and justification required

All artifacts were examined according to the algebra content strand specifically focused on functions of the NCTM *Principles and Standards* to determine the intent to help students achieve the following:

- Generalize patterns using explicit and recursive functions
- Understand and use various representations for relations and functions
- Investigate rates of change, intercepts, zeros, asymptotes, and local and global behavior
- Implementation of manipulatives and technology (NCTM, 2000).

**Table 3.9: Characteristics of a Standards-based classroom: Process Standards**

	Student	Evidence	Teacher	Evidence	Artifacts	Evidence	Assessment	Evidence
PROCESS STANDARDS								
Standards-based Problem Solving	Solving real world problems collaboratively	Survey 13, 19,21,24,31, 32 Observation Artifacts	Provide opportunities for problem based learning	Survey 13,19 Artifacts Interview 2,3 Observation	Accessible to all students		Formal	Artifacts Interview 4
Communication			Encouraging communication among students and with students	Survey 13,21	Challenging for all students		Informal	Survey 27, 28 Interview 4
Representations	Use technology and manipulatives	Survey 14 Observations	Encourage use of technology and manipulatives	Survey 14 Observation	Connections to other areas of mathematics		Guides Instruction	Interview 4
Representations and Connections	Approach problems from multiple perspectives	Survey 15,20 Observation	Teacher asks questions that cause students to think divergently and connect information to previous material and other curriculum	Survey 15, 24, 25 Observation	Connections to other subject matter		Open ended responses	Survey 30 Interview 4
Representations and Connections			Approach problems from multiple perspectives	Survey 15,18,22 Observation	Potential for multiple solutions		Performance tasks	Survey 31, 32 Interview 4
Representations	Use multiple representations	Survey 15, 18,20,22	Use multiple representations	Survey 15, 18,20,22 Observation	Potential for scaffolding			
Communications, Problem Solving, Reasoning	Making, refining, exploring, proving conjectures	Survey 16,23 Observation	Emphasis on student exploration instead of teacher explanation	Survey 18, 24 Observation Interview 2,3	Potential for communication			
Reasoning, Connections	Reasoning and justifying of solutions	Survey 16 Observation Artifacts	Make connections to old and new content Provide opportunities for students to be part of the learning process	Survey 25 Observation	Potential for multiple representations			
Problem Solving	Solving problems independently	Survey 17, 19, 31 Observation Artifacts	Focus on concepts and procedures with understanding	Survey 25	Higher order thinking skills			
Communication	Communicating ideas, explaining procedures	Survey 23, 26, 27 Observation	Teacher presents the mathematical ideas through various methods Teacher and students communicate with each other	Observation Artifacts				
Connections And Principles	Evidence students understand key concepts	Observation,	Make connections to previous math other disciplines Informal assessments as lesson progresses Assist students in noticing and correcting inconsistencies in their thinking	Interview 4 Pre-Ob 4				
Principles	All ideas are treated with respect	Survey 26 Observation	Students ask questions that direct the lesson	Survey 34 Observation				
Principles	Actively engaged in learning process	Observation Artifacts	Integrate questioning strategies and activities that assist students in being active members of the learning process					



**Table 3.10: Characteristics of a Traditional Classroom**

	Student	Evidence	Teacher	Evidence	Artifacts	Evidence	Assessment	Evidence
Non Standards-based Practices	Only textbook and worksheet questions	Survey 35 Artifacts Interview 2-4	Only whole group explanation	Survey 33 Observation	Short answer tests	Survey 38		
	Only read from a text without interpretation	Survey 36 Observation	Read from a text without discussion	Survey 36 Observation	Work problems at the board without meaning	Survey 39		
	Practice facts rules or formulas without meaning or context	Survey 37 Artifacts Interview 2-4						
	Memorization without context							

**Table 3.11: Characteristics of a Standards-based classroom: Content Standards**

	Student	Evidence	Teacher	Evidence
<b>Algebraic Content Standards</b>				
Understand patterns relations and functions	Generalize patterns using explicit and recursive functions	Observation Artifacts	Create opportunities for students to look at various patterns and use abstraction when appropriate	Interview, Observation
	Use various representations of functions	Artifacts	Provide opportunities to use various representations in various contexts	Observation
	Analyze rates of change, intercepts, zeros, asymptotes, local and global behavior	Observation	Provide various methods to analyze these through technology and algebraic methods	Observation
	Understand and use transformations	Observation	Look at patterns involved in transformations	Observation
Represent and analyze mathematical situations and structures using algebraic symbols	Understand and use equivalent forms	Artifacts, Observation	Use and practice various forms	Observation
	Use symbolic algebra	Artifacts	Create a need and use for symbolic algebra	Observation, Artifacts
Use models to represent and understand quantitative relationships	Determine the class of functions that might model a quantitative relationship	Artifacts	Expose students to a variety of different functions and the real-world application of each model	Observation, Artifacts
Analyze change in various contexts	Approximate and interpret rates of change from graphical and numerical data		Analyze, approximate, and interpret rates of change from graphical and numerical data	Observation, Interview, Artifacts

## Instrument Validity

### *Survey*

Questions for Section II of the current survey were taken directly from the survey used by McCaffrey et al. to determine the level of implementation of the Standards in schools. An exploratory factor analysis was conducted by McCaffrey et al. (2002) which led to the creation

of the two different scales (standards-based and traditional practices). Each scale was the simple average of individual items scored on a five-point scale. From this work McCaffrey et al. (2002) reports a reliability coefficient of  $\alpha = 0.90$  for the standards-based practices and  $\alpha = 0.34$  for the traditional practices. In a study reported by Klein (2000), the pooled analysis of relationships between instructional practices and student achievement in six elementary and middle schools, the reliability was similar for standards-based practices, but for the traditional practices section was found to be about 0.70.

### **Ensuring Trustworthiness**

The purpose of trustworthiness in any qualitative study is to support the argument that the inquiry's findings are "worth paying attention to" (Lincoln & Guba, 1985, p.290). According to Lincoln & Guba (1985), four issues of trustworthiness demand attention: credibility, transferability, dependability, and confirmability.

Credibility is an assessment of whether the research results do an accurate job of representing the data in its original context (Lincoln & Guba, 1985). Lincoln & Guba (1985) recommend accurate and adequate documentation of changes and surprises in order to enhance credibility through the use of triangulation of data, peer debriefing, and member checks. The researcher implemented triangulation and member checks.

First, the researcher made use of multiple and different methods of investigation in order to substantiate the evidence discovered throughout each phase of the study. Information was gathered through surveys, interviews, observations, and artifact analysis. In order to correlate the different types of data, survey questions were grouped into three categories (demographics, standards-based, and traditional) so that responses during the interview and observations could be compared directly to the survey responses. This technique allowed the researcher to better determine the extent to which teachers in high and low performing schools implemented standards-based practices. The interviews and observation provided rich, thick description which supported the responses from the survey and allowed the researcher to triangulate data.

Second, member checks were completed with each of the participants in Phase II of the study. Each participant reviewed a summary of the interview and observation and were given the opportunity to offer comments on whether or not they felt the data accurately represented the

observation and/or interview. These member checks were used to assess the teacher's intentions, clarify any misunderstandings, and correct any errors.

Transferability implies that the results can be generalized to other settings, situations, populations, and circumstances. Rich, thick description and purposeful sampling are both recommended by Lincoln & Guba (1985) to enhance transferability. Transferability was addressed by using a survey from previous research by McCaffrey et al. which is available in Appendix C. The purposeful sampling of matched pairs of teachers from high and low performing schools and the rich thick descriptions of classroom observations and interviews will assist the reader in transferring the results to other settings. In addition, the data analysis documents are available upon request. This will allow other researchers the ability to transfer the conclusions to other studies or to repeat this study.

Dependability is an evaluation of the quality of the processes of data collection, data analysis, and developing relevant conclusions. It can be argued that establishing credibility also establishes dependability; however, triangulation and an audit trail are methods that can be used to enhance dependability. Finally, confirmability is the same as objectivity according to Lincoln and Guba. By demonstrating that the study followed a smooth and logical progression from the design phase through the drawing of conclusions and eliminating any potential researcher bias, the researcher can demonstrate confirmability. In this inquiry, trustworthiness was enhanced through the strategies detailed below.

Dependability and confirmability were assured through matching schools to eliminate confounding variables, clarifying researcher bias, and audit trails. Four high performing and four low performing schools were matched using data collected through the survey and the KSDE website to eliminate variables such as SES, location to a larger city, LEP students, and minority students. Researcher bias was clarified in the section addressing limitations of the study. An auditor examines the inquiry process, findings, interpretations, and recommendations. Lincoln and Guba suggest a single thorough audit should be sufficient (1985). Mr. Keith Dreiling is a mathematics instructor at Fort Hays State University and was the external auditor for this study. He was in the process of finishing his Ph.D. in Curriculum and Instruction and was familiar with qualitative methods of research. After the researcher completed the data analysis, the auditor examined all data analysis documents and comments from member checks.

## Summary

The NCTM *Principles and Standards* describes a future in which all students have access to rigorous, high quality mathematics instruction (NCTM, 2000), while the Standards Impact Research Group (SIRG) suggests that understanding the impact of the standards on teachers and ultimately on student achievement must be understood (Lester & Ferinni-Mundy, 2004).

Through the use of surveys, interviews, observation, and artifacts, the researcher examined the behaviors of rural teachers in Kansas with respect to the NCTM *Principles and Standards*. The researcher hoped to discover patterns between teachers at high and low performing schools and the impact these actions might have on students' learning of mathematics. Chapter 4 presents the results collected. Conclusions and recommendations for future research are shared in Chapter 5.

## **CHAPTER 4 - Results**

### **Introduction**

Quantitative and qualitative data were gathered and analyzed to answer the research questions. The analysis presented in this chapter was divided into two parts consisting of quantitative data first (Phase I) and qualitative data second (Phase II). Phase I presents an examination of the demographic characteristics and teaching practices of all teachers at high performing schools based on responses from the survey followed by an examination of the same data for all teachers from low performing schools. Data were analyzed to determine any patterns or trends among and between the two groups. The summary of Phase I compares and contrasts results from teachers at high and low performing schools.

Phase II includes qualitative data gathered from surveys, observations, interviews, and artifacts from the four matched pairs. First, results concerning teaching practices taken from the surveys are compared from the teachers of both high and low performing schools from the four matched pairs. Demographic data between matched pairs were not compared as they were used to create the matches. Second, interview data from teachers at high performing schools followed by those from low performing schools are presented. A more indepth analysis and comparison of interview data from each matched pair is given. Observation and artifact results are presented in a similar fashion by presenting the data from high performing schools first, low performing schools second, followed by a comparison of data from matched pairs.

Data from all four sources: surveys, interview, observation, and artifacts were then used to triangulate data. High performing schools are examined first followed by low performing schools. The analysis ends with a summary of the triangulation by comparing the data from high and low performing schools. Throughout the chapter, results from high performing schools are reported first followed by the results from low performing schools.

## PHASE I – Survey Analysis

The survey instrument used in this study was divided into two sections. The first section of the survey, questions 1-12, was used to determine demographics, levels of training, and familiarity with the *Principles and Standards*. The second section of the survey, questions 13-39, was used to assess classroom practices both traditional and those aligned with the NCTM *Principles and Standards*. These data were analyzed using the Statistical Package for the Social Sciences (SPSS v. 12.0). Using a t-test for equality of means, responses of teachers from high and low performing schools were compared. Data from high performing schools is presented first followed by those from low performing schools second.

### *Teachers at High Performing Schools*

#### *Demographic Data*

Frequencies and percentages of survey responses from survey questions 1-12 were calculated to determine any patterns among teachers from high performing schools.

**Table 4.1: Years of Experience of Teachers at High Performing Schools**

Teaching Experience	Percentage
1-5 years	21.7%
6-14 years	39.1%
15-24 years	26.1%
25+	13%

Of the sixty teachers from high performing schools receiving surveys, 23 teachers responded. Fifty-two percent of the teachers in high performing schools were female with an average age of 41.6 years. Nearly 70% of these teachers completed their training in the 1970s or in the 1990s with only 4% receiving their training after 2000. As can be evidenced in Table 4.1, forty percent of teachers had between six and fourteen years of experience in the classroom with nearly all of that occurring at the current school.

**Table 4.2: Coursework of Teachers at High Performing Schools**

Training	Percentages
None	4.3%
Initial Training	21.7%
Additional Coursework without a degree	43.5%
Graduate degree with a major in math or math education	26.1%

Table 4.2 illustrates approximately 44% of teachers completed additional coursework in mathematics education with 25% completing an advanced degree with a major or specialty in mathematics education. Almost 26% of teachers received no training or any additional training beyond their initial degree. One person abstained from answering this question therefore the percentages in Table 4.2 do not add up to 100%. All teachers reported having some knowledge of the NCTM *Principles and Standards* with 70% of teachers reporting they have read them.

**Table 4.3: Number of Students in Class at High Performing Schools**

Number of students	Percentage
Less than 10	34.8%
11-15	52.2%
16-20	13%
21-25	0%

Teachers at high performing schools reported teaching between 3 and 7 classes per day with an average of 11 students in each class. No teachers from high performing schools reported having more than twenty students in class. Results from Question 8 concerning the number of students in mathematics class are available in Table 4.3. Nearly half of the teachers reported teaching at least one class other than mathematics throughout the day. Teachers and students from high performing schools met in mathematics class for approximately five hundred minutes per two week period with a standard deviation of twenty-nine minutes.

***Practices Aligned with the NCTM Process Standards in High Performing Schools***

Survey questions concerning classroom practices (13-39) were sorted into six categories: Problem Solving, Reasoning, Communication, Connections, Representations, and Traditional Practices. The sums of individual responses were calculated to determine values for each of the six categories. Questions 15, 19, 21, 23, 24, and 34 were used to assess Problem Solving in the classroom. Questions 16 and 30 were used to assess Reasoning. The Communication Standard was assessed using questions 13, 16, 21, 23, 26, and 33. Questions 15, 24, and 25 were used to assess Connections. Representations were assessed using questions 14, 18, 20, and 22. Finally, Traditional Practices were assessed using questions 33, 35, 36, 37, 38, and 39. Data from these six categories were then compared with data from four demographic questions: when teachers received their initial degree, the number of years of teaching experience, extent of formal college training in mathematics education, and awareness of the NCTM *Principles and Standards*. These data were analyzed to examine similarities and differences in rural teachers’ teaching practices in high and low performing schools.

**Table 4.4: Demographics vs. Teaching Practices in High Performing Schools**

		Problem Solving	Reasoning	Communication	Connections	Representation	Traditional Practices
Year Training Received	Pearson Correlation	-.243	-.244	-.001	-.200	-.315	.018
	Sig. (2-tailed)	.277	.263	.997	.360	.164	.935
	N	22	23	22	23	21	23
Years Of Experience	Pearson Correlation	.676*	.411	.314	.595	.559	.029
	Sig. (2-tailed)	.001	.051	.155	.003	.008	.897
	N	22	23	22	23	21	23
Math Education	Pearson Correlation	.176	.250	-.212	.289	.002	-.214
	Sig. (2-tailed)	.446	.262	.356	.191	.996	.339
	N	21	22	21	22	20	23
Knowledge Of Standards	Pearson Correlation	.082	.295	-.063	.184	.017	.072
	Sig. (2-tailed)	.717	.171	.779	.401	.941	.745
	N	22	23	22	23	21	23

\*p<.002 (A Bonferroni adjustment of .05/24)



Classroom practices and selected demographic characteristics were compared using correlation analysis to determine relationships. The results of this analysis are displayed in Table 4.4. A Bonferroni adjustment was made to the alpha level (.05/24) to reduce the risk of a Type I error. The number of years of teaching experience was found to have a significant positive relationship to the frequency problem solving was incorporated into the classroom [ $r(22)=.676$ ,  $p<.001$ ]. No significant relationship was found between years of experience, extent of math education, and the knowledge of the NCTM *Principles and Standards* with the integration of standards-based teaching practices into the classroom.

Classroom practices and selected demographic characteristics were also compared using correlation analysis to determine relationships between the chosen demographic data, incorporation of standards-based practices, and gender. The results of this analysis are displayed in Table 4.5 and 4.6.

**Table 4.5: Demographics vs. Teaching Practices in High Performing Schools (Female)**

		Problem Solving	Reasoning	Communication	Connections	Representation	Traditional Practices
Year Training Received	Pearson Correlation	-.011	-.163	-.058	.086	.155	.244
	Sig. (2-tailed)	.975	.633	.866	.801	.649	.470
	N	11	11	11	11	11	11
Years Of Experience	Pearson Correlation	.393	.371	.419	.332	.047	.000
	Sig. (2-tailed)	.232	.262	.200	.319	.891	1.000
	N	11	11	11	11	11	11
Math Education	Pearson Correlation	.000	.571	.060	.000	-.163	.000
	Sig. (2-tailed)	1	.067	.860	1.000	.633	1.000
	N	11	11	11	11	11	11
Knowledge Of Standards	Pearson Correlation	.421	.917*	.537	.450	.051	.505
	Sig. (2-tailed)	.197	.000	.089	.165	.882	.113
	N	11	11	11	11	11	11

\* $p<.002$  (A Bonferroni adjustment of .05/24)

**Table 4.6: Demographics vs. Teaching Practices in High Performing Schools (Male)**

		Problem Solving	Reasoning	Communication	Connections	Representation	Traditional Practices
Year Training Received	Pearson Correlation	-.602	-.594	-.204	-.563	-.801	-.205
	Sig. (2-tailed)	.086	.070	.598	.090	.009	.571
	N	9	10	9	9	9	10
Years Of Experience	Pearson Correlation	.881*	.715	.412	.773	.777	.309
	Sig. (2-tailed)	.002	.020	.270	.009	.014	.385
	N	9	10	9	10	9	10
Math Education	Pearson Correlation	.214	-.101	-.334	.464	-.047	-.229
	Sig. (2-tailed)	.612	.796	.418	.208	.911	.553
	N	8	9	8	9	8	9
Knowledge Of Standards	Pearson Correlation	.000	-.126	-.270	.169	-.903	-.245
	Sig. (2-tailed)	1.000	.728	.482	.642	.811	.496
	N	9	10	9	9	9	10
*p<.002 (A Bonferroni adjustment of .05/24)							

After a Bonferroni adjustment was made to the alpha level (.05/24) to reduce the risk of a Type I error, a significant positive relationship was found between female teachers’ knowledge of the standards and use of reasoning in the classroom [ $r(11)=.917, p<.002$ ]. A significant positive relationship was also found between the amount of teaching experience and the incorporation of problem solving in the classroom for male teachers [ $r(9)=.881, p<.002$ ].

Questions 13-18 asked teachers to rate how often they perform certain activities in their mathematics instruction. Percentages for each category are available in Table 4.7.

**Table 4.7: Standards-Based Teaching Practices in High Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Arrange seating to facilitate group work	4.3%	26.1%	39.1%	17.4%	8.7%
Encourage students to use manipulatives	0%	30.4%	43.5%	21.7%	4.3%
Ask students to look for alternative methods for solving a problem	0%	8.7%	34.8%	30.4%	26.1%
Explain a new topic using multiple representations	0%	4.3%	39.1%	30.4%	26.1%

Nearly 40% of teachers at high performing schools reported arranging seating to facilitate small group work, encouraging students to use manipulatives, and asking students to look for alternative methods for solving a problem, as well as explaining a new topic using multiple representations once or twice per month. Of the teachers from high performing schools responding to the survey, 43.5% reported they require students to explain their reasoning when giving an answer once or twice per week while an equal percentage reported that they do the same on a daily basis. Forty percent of teachers at high performing schools reported never or rarely allowing students to work at their own pace.

Questions 19-26 asked teachers to rate how often students in their mathematics classes engage in certain activities as part of their mathematics instruction. The detailed statistics are available in Table 4.8.

**Table 4.8: Student Activities in High Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Students work on solving a real world problem	0%	8.7%	26.1%	34.8%	26.1%
Students record, represent, or analyze data	4.3%	21.7%	43.5%	21.7%	4.3%
Collaborate with other students in solving a problem	0%	0%	43.5%	34.8%	2.7%
Students are required to write a description of a plan, procedure or problem-solving process	4.3%	43.5%	39.1%	8.7%	4.3%
Students work on extended mathematics investigations, projects, or make formal presentations	34.8%	60.9%	4.3%	0%	0%
Students draw connections between previously learned content and new material	0%	0%	17.4%	47.8%	34.8%

Sixty percent of teachers in high performing schools reported that students work on solving a real world problem at least once or twice per week while only 26% report that students record, represent, or analyze data with the same frequency. All students had the opportunity to collaborate with other students in solving a problem at least once or twice per month with 56% of these students collaborating at least once or twice per week. Fewer than 13% of students were required to write a description of a plan, procedure or problem-solving process at least once or twice per week with almost half of students (49%) receiving the same requirement at most once or twice per month. Only 4.3% of students worked on extended mathematics investigations, projects, or made formal presentations once or twice per month while the other 95.7% of students worked on an extended mathematics investigation or gave presentations at most once or twice per year. All students were encouraged to draw connections between previously learned content and new material at least once or twice per month.

The next set of questions asked teachers to determine how often students completed written work in their mathematics classrooms. Over 95% of teachers at high performing schools had students write reflections about something they had learned or collect their best mathematics

work in a portfolio at most once or twice a year. The remaining five percent of teachers had students practice this behavior at least once or twice a week.

Questions 29-32, and 34 had teachers reflect on the standards-based practices used to assess students' progress in mathematics while questions 33, and 35-39 examined more traditional practices. Table 4.9 displays the detailed results of the survey from teachers in high performing schools.

**Table 4.9: Assessment Practices in High Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Assess students' notebooks/journals	52.2%	13%	26.1%	0%	8.7%
Give test questions requiring open-ended responses	13%	30.4%	52.2%	4.3%	0%
Give short answer tests questions	13%	13%	60.9%	8.7%	4.3%
Complete performance tasks individually	4.3%	17.4%	26.1%	26.1%	26.1%
Complete performance tasks in groups	13%	26.1%	56.5%	0%	4.3%
Students work problems at the board	4.3%	4.3%	34.8%	47.8%	8.7%

Only 8.7% of teachers assessed students' notebooks/journals more than once or twice per week, while 52.2% of teachers from high performing schools never reviewed students' notebooks/journals. Over 95% of teachers gave test questions requiring open-ended responses at most once or twice per month while 87% of the teachers gave short answer tests at the same frequency. It should be noted that in the average classroom, tests are only given once or twice per month. Of those teachers requiring students to complete performance tasks, 75% reported students in high performing schools complete performance tasks individually at least once or twice per month while 60% reported completing performance tasks in groups at least once or twice per month. At the same time 90% of teachers reported having students work problems at the board at least once or twice per month.

The last two sections of the survey examined teacher’s instructional techniques. Nearly 83% of teachers in high performing schools explained new mathematics content to the entire class on a daily basis. Only 13% used a problem solving task for students to discover the mathematical concept before more formal explanation only once or twice per week. Nearly 83% of teachers had students answer textbook/worksheet questions daily. Almost 70% of students were required to read from their mathematics textbook at least once or twice per week. Almost 74% of students were required to practice math facts, rules or formulas daily. Detailed results of each question are given in Table 4.10.

**Table 4.10: Teaching Practices in High Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Explain new mathematics content to the entire class	0%	0%	4.3%	13%	82.6%
Use a problem solving task for students to discover the mathematical concept before more formal explanation	4.3%	17.4%	65.2%	13%	0%
Students answer textbook/worksheet questions	0%	0%	0%	17.4%	82.6%
Students are required to read from their mathematics textbook	13%	13%	4.3%	47.8%	21.7%
Students are required to practice math facts, rules or formulas	0%	8.7%	17.4%	30.4%	43.5%

## *Teachers at Low Performing Schools*

### *Demographic Data of Teachers at Low Performing Schools*

Frequencies and percentages of survey responses from survey questions 1-12 were calculated to determine any patterns among teachers from low performing schools. Fifty-three teachers from low performing schools responded out of the 140 surveys sent. Fifty-six percent of the teachers at low performing schools were female with an average age of 43.4 years. Thirty-three percent of teachers had between one and five years of teaching experience but only 19% of those teachers had been in their current district for the entire time. Table 4.11 displays the distribution of teaching experience for those teachers in low performing schools.

**Table 4.11: Years of Teaching Experience at Low Performing Schools**

Teaching Experience	Percentage
1-5 years	33.3%
6-14 years	35.2%
15-24 years	13%
25+	18.5%

Nearly one fourth of teachers in low performing schools received their training in the 1960s compared to the 13% of those teachers in high performing schools. Thirty percent of teachers received their training in the 1990s with nearly 15% receiving their training in the 70s, 80s, or after the year 2000. Only 2% of the teachers received no training in mathematics education while 32% received no additional training beyond their initial training which can be viewed in Table 4.12. Forty-three percent took additional coursework with 24% completing a degree with a major or specialty in mathematics education. Seventy percent of teachers at low performing schools reported having read *Principles and Standards* while all teachers reported having some knowledge of *Principles and Standards*.

**Table 4.12: Level of Mathematics Education of Teachers in Low Performing Schools**

Training	Percentages
None	1.9%
Initial Training	31.5%
Additional Coursework without a degree	42.6%
Graduate degree with a major in math or math education	24.1%

Teachers at low performing schools reported teaching between one and ten classes per day with an average of 14 students in each class. Thirty percent of teachers reported teaching at least one class other than mathematics throughout the day. Nearly five hundred minutes of mathematics class time were scheduled every two weeks with a standard deviation of 46 minutes and one third of these schools falling beyond one standard deviation.

***Practices Aligned with the NCTM Process Standards in Low Performing Schools***

The same six categories of Problem Solving, Reasoning, Communication, Connections, Representations, and Traditional Practices were compared with the four demographic questions: when teachers received their initial degree, the number of years of teaching experience, extent of formal college training in mathematics education, and awareness of the NCTM *Principles and Standards*. Similarities and differences were examined by comparing levels of training and knowledge of the *Principles and Standards* against perceived classroom practices. Frequencies and percentages were also computed for each category to gain a better understanding of teacher’s classroom behavior in low performing schools, as well as an understanding of those underlying beliefs.

Classroom practices and selected demographic characteristics were compared using correlation analysis to determine relationships. The results of this analysis are displayed in Table 4.13.



**Table 4.13: Demographics vs. Teaching Practices in Low Performing Schools**

		Problem Solving	Reasoning	Communication	Connections	Representation	Traditional Practices
Year Training Received	Pearson Correlation	-.081	-.307	-.089	-.126	-.184	.154
	Sig. (2-tailed)	.566	.024	.529	.370	.191	.267
	N	52	54	53	53	52	54
Years Of Experience	Pearson Correlation	.152	.256	.268	.051	.043	-.076
	Sig. (2-tailed)	.283	.062	.052	.716	.764	.587
	N	52	54	53	53	52	54
Math Education	Pearson Correlation	.103	.118	.107	.172	.208	.119
	Sig. (2-tailed)	.465	.396	.447	.219	.138	.393
	N	52	54	53	53	52	54
Knowledge Of Standards	Pearson Correlation	.450*	.394	.363	.540*	.119	-.033
	Sig. (2-tailed)	.001	.003	.008	.000	.393	.815
	N	52	54	53	53	54	54

\*p<.002 (A Bonferroni adjustment of .05/24)

A Bonferroni adjustment was made to the alpha level (.05/24) to reduce the risk of a Type I error. A significant positive correlation was found between teachers knowledge of the NCTM *Principles and Standards* and use of problem solving in the classroom [r(52)=.450, p<.002]. There was also a correlation between increased knowledge of *Principles and Standards* and students making more connections in the mathematics classroom [r(53)=.540, p<.002]. No significant relationship was found between years of experience, extent of math education, and amount of mathematics education with the integration of standards-based teaching practices into the classroom.

Classroom practices and selected demographic characteristics were also compared using correlation analysis to determine relationships between the teaching practices, incorporation of standards-based practices, and gender. The results of this analysis are displayed in Table 4.14.

**Table 4.14: Demographics vs. Teaching Practices in Low Performing Schools (Female)**

		Problem Solving	Reasoning	Communication	Connections	Representation	Traditional Practices
Year Training Received	Pearson Correlation	-.084	-.315	.028	-.122	.001	.297
	Sig. (2-tailed)	.664	.090	.887	.520	.955	.110
	N	29	30	29	30	30	30
Years Of Experience	Pearson Correlation	.219	.349	.260	.150	.149	-.085
	Sig. (2-tailed)	.254	.059	.174	.428	.433	.654
	N	29	30	29	30	30	30
Math Education	Pearson Correlation	.089	.073	-.066	.076	.036	.058
	Sig. (2-tailed)	.647	.703	.734	.688	.849	.759
	N	29	30	29	30	30	30
Knowledge Of Standards	Pearson Correlation	.461	.556*	.376	.618*	.369	.069
	Sig. (2-tailed)	.012	.001	.044	.000	.045	.715
	N	29	30	29	30	30	30
*p<.002 (A Bonferroni adjustment of .05/24)							

After a Bonferroni adjustment was made to the alpha level (.05/24) to reduce the risk of a Type I error, a significant positive relationship was found between female teachers' knowledge of the standards with use of reasoning in the classroom [ $r(30)=.556$ ,  $p<.002$ ] as well as between the amount of teaching experience and students making connections [ $r(30)=.681$ ,  $p<.002$ ]. There were no significant correlations between teaching practices and demographics for male teachers in low performing schools.

Table 4.15 displays the results of Questions 13-18 which asked teachers to rate how often they perform certain activities in their mathematics instruction.

**Table 4.15: Standards-Based Teaching Practices in Low Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Arrange seating to facilitate group work	0%	18.5%	35.2%	29.6%	16.7%
Encourage students to use manipulatives	5.6%	40.7%	29.6%	16.7%	7.4%
Ask students to look for alternative methods for solving a problem	1.9%	1.9%	29.6%	48.1%	16.7%
Explain a new topic using multiple representations	0%	1.9%	22.2%	46.3%	27.8%

Nearly 50% of teachers at low performing schools reported arranging seating to facilitate small group work at least once a week. Three fourths of these teachers reported encouraging students to use manipulatives in solving a problem less than twice a month. Almost 95% of teachers reported explaining a new topic using multiple representations while requiring students to look for alternative methods when solving a problem and explain their reasoning of solutions more than once per month. Less than 50% of teachers at low performing schools reported allowing students to work at their own pace more than once or twice per month.

Questions 19-26 asked teachers to rate how often students in their mathematics classes engaged in certain activities as part of their mathematics instruction with complete results in Table 4.16.

**Table 4.16: Student Activities in Low Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Students work on solving a real world problem	0%	1.9%	18.5%	53.7%	25.9%
Students record, represent, or analyze data	1.9%	20.4%	46.3%	24.1%	7.4%
Collaborate with other students in solving a problem	0%	1.9%	13%	46.3%	37%
Students are required to write a description of a plan, procedure or problem-solving process	9.3%	33.3%	46.3%	9.3%	1.9%
Students work on extended mathematics investigations, projects, or make formal presentations	27.8%	50%	16.7%	5.6%	0%
Students draw connections between previously learned content and new material	0%	5.6%	16.7%	27.8%	50%

Over 75% of teachers in low performing schools reported having students solve real world problems and draw connections between previously learned content and new material on a weekly basis while only 32% had students record, represent, and analyze data with the same frequency. Eighty percent of teachers at low performing schools allowed their students to work with others while solving a problem at least a bi-weekly. Students in low performing high schools were less likely to work on extended mathematics projects or report on them; however 58% of students were expected to write a description of a plan, procedure, or problem solving process at least once per month.

The next set of questions asked teachers from low performing schools to determine how often students complete written work in their mathematics classrooms. In addition to writing

during problem solving, 32% of students at low performing schools were required to write reflections about something they learned more than once per month while 26% collected their best mathematics in a portfolio with the same frequency.

Questions 29-32 had teachers reflect on the standards-based practices used to assess students' progress in mathematics while questions 38-39 examined more traditional practices. In Table 4.17, fifty-three percent of teachers from low performing schools reported giving tests that require open ended responses once or twice per month while 37% reviewed student notebook/journals with the same frequency. Students in low performing schools completed performance tasks individually (46%) and in groups (28%) at least once or twice per week.

**Table 4.17: Assessment Practices of Teachers in Low-Performing High Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Assess students' notebooks/journals	25.9%	22.2%	37%	9.3%	5.6%
Give test questions requiring open-ended responses	5.6%	24.1%	53.7%	14.8%	1.9%
Give short answer tests questions	11.1%	18.5%	38.9%	27.8%	3.7%
Complete performance tasks individually	9.3%	14.8%	27.8%	29.6%	16.7%
Complete performance tasks in groups	14.8%	22.2%	35.2%	24.1%	3.7%
Students work problems at board	3.7%	7.4%	35.2%	35.2%	18.5%

The last section of the survey questions teacher's instructional techniques which are examined in detail in Table 4.18.

**Table 4.18: Teaching Practices in Low-Performing Schools**

Activity	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost daily
Explain new mathematics content to the entire class	0%	1.9%	5.6%	13%	79.6%
Use a problem solving task for students to discover the mathematical concept before more formal explanation	5.6%	22.2%	42.6%	22.2%	5.6%
Students answer textbook/worksheet questions	1.9%	0%	0%	16.7%	81.5%
Students are required to read from their mathematics textbook	7.4%	13%	31.5%	22.2%	25.9%
Students are required to practice math facts, rules or formulas	1.9%	1.9%	5.6%	38.9%	51.9%

Nearly 80% of teachers from low performing schools reported explaining new mathematics to the entire class and having students complete textbook/worksheet questions on a daily basis while only 28% reported using a problem solving task for students to discover the mathematical concept before moving to more formal explanation at least once per week. Almost half of teachers reported having students read from the mathematics textbook in class at least once per week, while 90% reported students practicing their math facts, rules, or formulas at the same frequency.

### ***Comparison of Survey Results between Teachers at High and Low Performing Schools***

Means were calculated from responses for demographic questions and teaching practices on the survey from teachers at high and low performing schools. These means of demographic data were then compared to each other and means of teaching practices were compared to each other using a two tailed t-test assuming unequal variances. An alpha level of .01 was chosen to adjust for the 39 comparisons. No significant relationships were found.

## PHASE II

An indepth analysis of the qualitative data gathered in Phase II of the study is presented next. Data gathered from surveys, observations, interviews, and artifacts from the four matched pairs is presented and compared to discover patterns among and between high and low performing schools. First, results taken from the survey concerning teaching practices are compared from the teachers of the four matched pairs. Second, interview results from teachers at high performing schools are presented followed by interview results from teachers in low performing schools. A more indepth comparative analysis of interview data from each matched pair follows. Observation and artifact results are presented in a similar fashion by presenting the data from high performing schools first, low performing schools second, followed by a comparison of data from matched pairs.

The four pairs of schools were chosen and matched based on results from the survey and information taken from the KSDE website. The school report card on the KSDE website was used to initially match high and low performing schools based on the following six characteristics: public or private, grade levels, size of grades, students eligible for free and reduced lunch (within 10%), percentage of minority students (within 10%), and percentage of students with limited English proficiency (within 10%) (KSDE, 2006). Data from the survey including years of teaching experience and willingness to participate in Phase II were then used to better align the matched pairs. Interviews, observation, and artifacts were focused on a unit covering functions in Algebra I and Algebra II classrooms of each matched school during the fall semester of 2006.

High performing and low performing schools were determined based on their performance on the Kansas Math Assessment during the 2003-2005 school years. Before indepth analysis, four matches were created using data from the KSDE website, survey questions 1-5, and teachers' willingness to participate in Phase II. The performance of schools before and after this two year window can be examined to gain a richer understanding of the trends in each school. Schools A, C and G all achieved Standard of Excellence in mathematics during the 2005-2006 school year. School E was the only high performing school not to achieve Standard of Excellence in mathematics during the 2005-2006 school year as they had the previous two years. School B met building wide Standard of Excellence in 2006 (although Grade 10 is reported as not having met Standard of Excellence on the KSDE website) but was the only low performing

school to record Standard of Excellence in the year 2006. Schools D, F and H did not achieve Standard of Excellence during the 2005-2006 school year.

It is important to note that teachers and administration in two of the four low performing schools had made drastic changes to their test preparation practices during the time of this study. Students at school B spent twenty minutes per day practicing for the state math assessment during January, February, and March of the 2005-2006 school year. School D implemented a test preparation class called Standards Math during the 2006-2007 school year in an attempt to increase student scores on the Kansas Math Assessment. These changes are considered in the analysis of data presented throughout Phase II.

## ***Survey Results***

### ***Comparison of Matched Pairs***

Survey results were compared for each of the matched pairs to determine any differences that may occur between the two high schools. Responses to the first six questions should be similar as the results were used to create the matched pairs. The results from the remaining questions are examined to determine potential differences in teachers' education and familiarity with the NCTM *Principles and Standards*. The frequency of implementing standards-based and traditional practices into the mathematics classroom between teachers from high and low performing schools was compared to discover any possible trends in the data.

#### ***Teacher A and Teacher B***

Teacher A, from a high performing school, and Teacher B, from a low performing school, were the first matched pair. When the schools were matched, Teacher A taught six different classes per day and Teacher B taught five different classes per day. During the 2005-2006 school year, Teacher B taught two mathematics classes and acted as the high school counselor for the remainder of the school day. Although the teaching schedules were not significantly different, Teacher A had each class for only 45 minutes per day while teacher B spent an additional seven minutes of class time with students per day. Both had similar years of experience and were aware of *Principles and Standards* but only Teacher A had read them.



When averaging the survey responses to standards-based classroom practices, Teacher B implemented standards-based practices only slightly more than Teacher A as can be evidenced in Table 4.19.

**Table 4.19: Comparison of Classroom Practices of Teacher A and B**

	Teacher A	Teacher B
Practices associated with Problem Solving	$\bar{x} = 3.0$ , Once or twice per month	$\bar{x} = 3.3$ , Between once or twice a month and once or twice per year
Practices associated with Reasoning	$\bar{x} = 3.5$ , Between once or twice a month and once or twice per year	$\bar{x} = 3.5$ , Between once or twice a month and once or twice per year
Practices associated with Communication	$\bar{x} = 3.17$ , Between once or twice a month and once or twice per year	$\bar{x} = 3.5$ , Between once or twice a month and once or twice per year
Practices associated with Connections	$\bar{x} = 3.0$ , Once or twice per month	$\bar{x} = 3.3$ , Between once or twice a month and once or twice per year
Practices associated with Representations	$\bar{x} = 3.0$ , Once or twice per month	$\bar{x} = 3.0$ , Once or twice per month
Traditional Practices	$\bar{x} = 3.85$ , Less than once or twice per week	$\bar{x} = 3.85$ , Less than once or twice per week

Teacher A reported students looking for alternative methods when solving problems, working at their own pace, writing reflections, and completing performance tasks more than Teacher B. Teacher B reported students work to solve a real world problem, collaborate with others, and draw connections between previously learned content and new material with more frequency than Teacher A. On average, each teacher implemented traditional practices with the same frequency, slightly less than once or twice per week.

### ***Teacher C and Teacher D***

The second match consisted of Teacher C from a high performing school and Teacher D from a low performing school. Each teacher had only four different preparations per day. Teacher C met with students for 51 minutes five days per week while Teacher D met two days per week for 90 minutes and one day for 45 minutes using a modified-block schedule. Both were aware of the NCTM *Principles and Standards* but only Teacher D had read them.

Teacher C from a high performing school and Teacher D from a low performing school each reported implementing standards-based practices somewhat less than once or twice per week. Both teachers reported implementing traditional practices at least once or twice per week as shown in Table 4.20.

**Table 4.20: Comparison of Classroom Practices of Teacher C and D**

	Teacher C	Teacher D
Practices associated with Problem Solving	$\bar{x} = 4.0$ , Once or twice per week	$\bar{x} = 3.67$ , Between once or twice per month and once or twice per week
Practices associated with Reasoning	$\bar{x} = 4.0$ , Once or twice per week	$\bar{x} = 3.5$ , Between once or twice per month and once or twice per week
Practices associated with Communication	$\bar{x} = 3.67$ , Between once or twice per month and once or twice per week	$\bar{x} = 4.3$ , More than once or twice per week
Practices associated with Connections	$\bar{x} = 3.67$ , Between once or twice per month and once or twice per week	$\bar{x} = 3.67$ , Between once or twice per month and once or twice per week
Practices associated with Representations	$\bar{x} = 4.0$ , Once or twice per week	$\bar{x} = 4.0$ , Once or twice per week
Traditional Practices	$\bar{x} = 4.0$ , Once or twice per week	$\bar{x} = 4.5$ , More than once or twice per week

Teacher C encouraged students to look for alternative methods for solving a problem, explain reasoning when giving an answer and work on solving real world problems somewhat more frequently than Teacher D. Teacher D arranged seating to facilitate group work, required students to give formal presentations, and had students collect their best mathematics work in a portfolio considerably more than Teacher C. In addition, Teacher D specifically encouraged the use of manipulatives, used multiple representations, encouraged students to draw connections between previously learned content and new material, and required students to journal and complete performance tasks only slightly more than Teacher C.

### ***Teacher E and Teacher F***

Teachers E and F were a very similar match in demographic data. Each had five years of teaching experience in the current district, taught five days per week for 50-55 minutes, and had both read *Principles and Standards*. Teacher E, from a high performing school, taught six classes per day with three different preparations. Teacher F had six different preparations per day. These two teachers reported implementing standards-based practices less frequently than any of the other matched pairs. Teacher E applied standards-based techniques only slightly less than Teacher F as shown in Table 4.21.

**Table 4.21: Comparison of Classroom Practices of Teacher E and F**

	Teacher E	Teacher F
Practices associated with Problem Solving	$\bar{x} = 2.17$ , Between once or twice a year and once or twice a month	$\bar{x} = 2.67$ , Between once or twice a year and once or twice a month
Practices associated with Reasoning	$\bar{x} = 2.5$ , Between once or twice a year and once or twice a month	$\bar{x} = 2.5$ , Between once or twice a year and once or twice a month
Practices associated with Communication	$\bar{x} = 3.67$ , Between once or twice per month and once or twice per week	$\bar{x} = 3.17$ , Between once or twice per month and once or twice per week
Practices associated with Connections	$\bar{x} = 2.67$ , Between once or twice a year and once or twice a month	$\bar{x} = 2.67$ , Between once or twice a year and once or twice a month
Practices associated with Representations	$\bar{x} = 3.0$ , Once or twice a month	$\bar{x} = 2.5$ , Between once or twice a year and once or twice a month
Traditional Practices	$\bar{x} = 3.75$ , Between once or twice a month and once or twice per week	$\bar{x} = 3.67$ , Between once or twice a month and once or twice per week

In the high performing school, students were encouraged to use manipulatives, explain reasoning, record, represent, and analyze data, write a description of a plan, as well as individually complete performance tasks more frequently than those students at the low performing school. Teacher F, in the low performing school, encouraged collaboration among the students, had students collect their best mathematics in a portfolio, and reviewed student notebooks with more frequency than her counterpart. In addition, Teacher F reported using a problem solving task for students to discover the mathematical concept before more formal explanation more often than Teacher E. Teacher E implemented traditional practices slightly more than Teacher F.

### ***Teacher G and Teacher H***

The final matched pair consisted of Teacher G from a high performing school and Teacher H from a corresponding low performing school. Both teachers had the same level of teaching experience, taught classes other than mathematics, and met for 50 minutes five days per week. Teacher G had read *Principles and Standards* while Teacher H was aware of them but reported not knowing much about them.

Again, there do not appear to be large differences between the survey results of the two teachers. Teacher G facilitated group work, the use of manipulatives, and extended investigations less frequently than Teacher H. Teacher G, from a high performing school, required students to draw connections to previously learned material and complete performance tasks individually much more frequently than Teacher H. Both teachers implemented traditional practices slightly more than once or twice per week. Specific practices and frequency of implementation are available in detail in Table 4.19.

**Table 4.22: Comparison of Classroom Practices of Teacher G and H**

	Teacher G	Teacher H
Practices associated with Problem Solving	$\bar{x} = 2.3$ , Between once or twice per month and once or twice per week	$\bar{x} = 2.67$ , Between once or twice a year and once or twice a month
Practices associated with Reasoning	$\bar{x} = 2.5$ , Between once or twice a year and once or twice a month	$\bar{x} = 3.5$ , Between once or twice a month and once or twice per week
Practices associated with Communication	$\bar{x} = 3.0$ , Once or twice a month	$\bar{x} = 3.17$ , Between once or twice a month and once or twice per week
Practices associated with Connections	$\bar{x} = 3.0$ , Once or twice a month	$\bar{x} = 2.3$ , Between once or twice per month and once or twice per week
Practices associated with Representations	$\bar{x} = 2.0$ , Once or twice a year	$\bar{x} = 2.75$ , Between once or twice per month and once or twice per week
Traditional Practices	$\bar{x} = 4.17$ , Slightly more than once or twice per week	$\bar{x} = 4.0$ , Once or twice per week

There appeared to be no consistent patterns in the implementation of standards-based practices associated with the Process Standards among matched pairs. Although, most teachers from low performing schools implemented standards-based practices slightly more frequently than their counterparts, each teacher implemented different standards-based practices and the majority of these practices were not implemented frequently. All teachers from low performing schools reported using group work or collaboration more frequently than their counterparts which was also supported by interview and observational data.

*Summary of Survey Results*

**Table 4.23: Survey Comparisons**

Teacher	Classroom practices implemented with more frequency than matched pair	Frequency of Implementation
<b>Teacher A</b> High Performing	Alternative methods, own pace, write reflections, complete performance tasks	Once or twice per month
<b>Teacher B</b> Low Performing	Solve real world problems, collaborate, draw connections between new and old material	A little less than once or twice per month
<b>Teacher C</b> High Performing	Alternative methods, explain reasoning, real world problems	A little less than once or twice per month
<b>Teacher D</b> Low Performing	Group work, explain reasoning, formal presentations, portfolio, manipulatives, multiple representations, connections, journal	Once or twice per week
<b>Teacher E</b> High Performing	Manipulatives, explain reasoning, data, write, complete performance tasks individually	Once or twice per year
<b>Teacher F</b> Low Performing	Collaboration, portfolio, review student notebooks, problem solving before formal instruction	A little more than once or twice per year
<b>Teacher G</b> High Performing	Did not implement any standards-based practices with more frequency than Teacher H	Once or twice per year
<b>Teacher H</b> Low Performing	Group work, manipulatives, extended investigations, draw connections, complete performance tasks individually	A little more than once or twice per year

### ***Interview Results***

Each teacher from the four purposefully selected matched pairs chosen in Phase I was interviewed using the interview protocol available in Appendix C. Seven different questions were asked during the interview to gain a better understanding of the curriculum at each school and more specifically in the algebra classes. Each question was analyzed to look for similarities and differences between and among teachers at high and low performing high schools. Results are first reported for teachers at high performing schools as an entire group followed by teachers from low performing schools as a group. The results of matched pairs are then compared to uncover possible similarities between teaching practices, school environment, and teacher beliefs.

#### ***Teachers at High Performing Schools***

Initially, each teacher from the high performing schools was asked how curriculum decisions were made in their district as well as the mathematics they teach in their classroom. All four teachers stated they had the freedom to choose what mathematics to teach in their own classrooms based on “what it is the students need to know and what will be tested” (Teacher A). Each teacher also mentioned heavy reliance on the state standards as well as the textbook to determine the content covered in the classroom. The idea that state assessments are the driving force in these classrooms can be substantiated by comments similar to those of Teacher G: “...we all pretty much rely on the state standards because ultimately what it comes down to is they (students) have to perform well on the state tests. That is what our curriculum is based upon.” It is important to note small schools do not have the funds to buy textbooks frequently. Teacher C stated that “books are good for eight to ten years;” however, all four teachers reported they rely heavily on the textbook to determine their curriculum. Teacher E “follows the book a lot” by picking and choosing those topics that match the district’s standards, while Teacher A follows closely to the text because of the pressure created from having five or six different preparations per day.

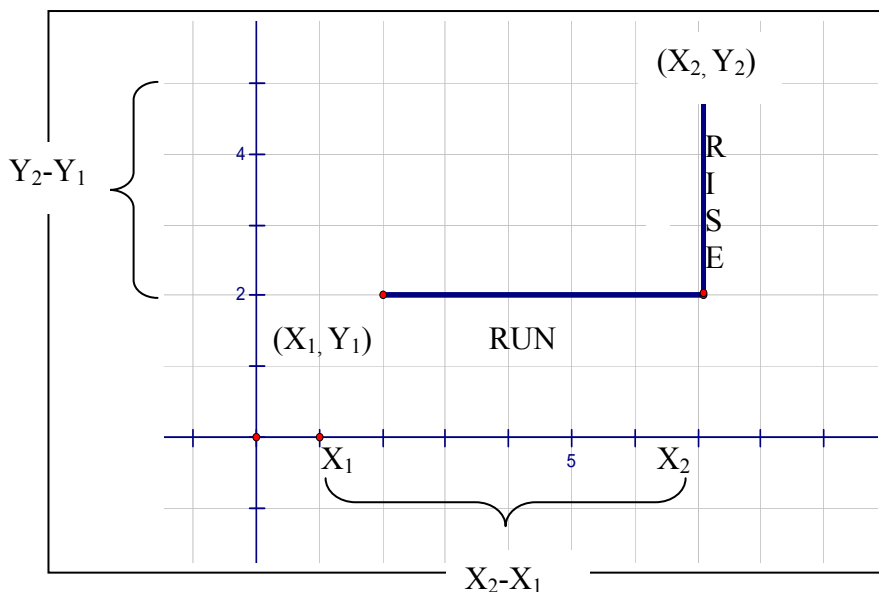
The second question of the interview asked teachers to describe a typical day in the classroom. Additional information about the classroom atmosphere and procedures was gathered during the observation of each teacher. Teacher A began each lesson with a warm-up exercise



that may be a review from the previous day's lesson, a quiz, or a question preparing the students for the content to be learned that day. Two of the four teachers gave students a completion grade on the homework and then had the students grade their own papers together in class. The other two teachers collected and graded the homework papers themselves on a daily basis. Teacher G stated that "3-4 hours per day is spent grading papers," circling errors, and providing written feedback. After papers are graded or questions are asked concerning the homework, Teacher E planned a short quiz over the homework to ensure the students understood the material. All four teachers planned to lecture about twenty minutes per day. Teacher C did not require students to take notes as the lecture material and examples came directly from the text. "They're supposed to take notes...but it's stuff out of the book...they have everything in the book then I go over it." Two of the teachers had their students take notes on a regular basis. Teacher G did not grade students on their notebooks but when they begin as freshman, it is strongly recommended that the students take notes. After the lecture, students were given time to begin the homework assignment. Only one of the teachers regularly planned group work during this time. The number of students in Teacher C's classroom was too small to support group work. Teacher G had enough students but "...keeps it fairly quiet in class because I believe a lot of that (the material) may have to be worked on their own and it has to be fairly quiet in class."

Question 3 asked teachers to describe their approach to a lesson on slope. Teacher A would begin the lesson with some examples and patterns asking students "...how do you get from point to point? How would you describe that change? And the standard way we use how much we change vertically and horizontally to get the definition of slope." The remaining three teachers began with the derivation of the formula. Teacher G "would start with the derivation of the formula to start as in  $m = \frac{y_2 - y_1}{x_2 - x_1}$ . I would plot two points and then show the distance between  $y_2$  and  $y_1$  and call that the rise and the distance between  $x_2$  and  $x_1$  and call that the run." Teacher G was drawing the diagram in Figure 4.1 while explaining the process to the researcher.

**Figure 4-1: Teacher G Explaining Slope**



The next question asked teachers to explain methods used to determine if students were progressing in math and what changes would be made based on their conclusions. Teacher C and G closely monitor student’s progress on homework as all of it is graded by the teacher. Both teachers also gave quizzes throughout each chapter. Teacher E only gave a completion grade on homework but usually gave a 5 point quiz every day to determine if students were doing their homework and understanding the material. “It is my way to say ‘hey did you try the homework and did you ask questions if you didn’t get it’ and if you are going to sit there and do neither then you are going to do bad on that (quiz)...” In addition, Teacher E’s school had a Power Period, which is a thirty-minute period before school for which attendance is required if a student has a “D” or “F” in a subject but all students were allowed and encouraged to come ask questions and get help as needed. Teacher G and E both had students come on a regular basis to seek individual help. “I harp on them a lot to get in before school and during class. As long as I’m not lecturing I say I will help them.” (Teacher G). Teacher E also states “...I have a lot of Algebra II students come in and I encourage them to do that. Work every problem you can at night, drop in for ten minutes and ask me the questions on the ones you don’t know...”

Determining the preparation teachers require of their students before the state assessments was the purpose of Question 5. All four teachers stressed the importance of covering the material throughout the year; however, each school district incorporated special preparation before giving the actual assessments. Teacher A, who was teaching in the middle

school during the 2003-2004 school year but taught in the high school the following year, was able to offer insights from both perspectives. The teacher before "...really pushed. They did state assessment questions daily. I don't know if they were taught to the test but they were very aware." Currently, Teacher A "teaches the things that need to be taught that the state has decided kids need to know by the time they get out of here...and highlights that this is something that they're going to expect you to know but not to dwell on it." "We did take the formative assessment online just so it wasn't the first time they ever saw anything like that. And then we took two to three days before the test and I printed a bunch of those kinds of questions and...they worked half a dozen at a time in each class. It was part of the curriculum, part of what we did, and then we kind of reviewed or refreshed."

Teacher C, E, and G had similar approaches by trying all year to cover the material. "Then last year about a week before we gave the state assessments we ran some stuff off the internet, some study examples... and then the three math teachers just split up the sophomore class into three groups. We went over examples in our AP (activity period) groups twenty minutes a day" (Teacher C). Teacher E had the students take a practice test on the computer and "...have them work through some practice problems just to give them more of a general overview of you know, here's a wide scope of what you might see on the test..." While Teacher G stated "throughout the years you kind of develop what the main focus of those concepts that are covered (on state assessments). In Algebra I, at the very end of our textbook, we have a section called Looking Ahead and it covers statistics, histograms, probability, stuff like that..." which are covered both in Algebra I and in geometry. "The state does put on their website some practice tests. Also I got some practice tests through Prentice Hall and Houghton Mifflin...we aren't just teaching to the test but at the same time we are emphasizing what the state tests."

Question 6 asked teachers to comment on what they believe attributes to the success of their students in mathematics. It was interesting to note that only one teacher commented on the small, rural school environment. Teacher A believed "that one thing that is really a benefit to our kids...is that I know almost every kid I have in class. I know who they are...and I can call home." Teachers C and G both put the responsibility to be successful back onto the students. "How much time they put into it themselves. The kids that don't do their homework, don't do very well. Coming to school, if kids don't come to school, they don't do very well" (Teacher C). In addition, Teacher G felt that getting the right type of help, taking notes, and really

understanding the why behind the question aids the students in being successful. Teachers G and E both placed some of the responsibility upon themselves for the success of their students. The attitude that the teacher brings to the classroom, the ability to hold students accountable, and being available to answer student's questions are all critical to student success according to these two teachers. In addition, Teacher E stated "another thing that is huge for them to be successful is finding different ways to present the same thing."

Finally, teachers were asked what hinders the success of their students in mathematics. Teacher A was the only one to comment on the fact that these students were in a rural area where "education isn't a priority." The other three teachers felt that students caused themselves to be unsuccessful. "...not doing their homework...you know what they say about 'practice makes perfect' is true in math. That would be the hindrance to them...not coming to school, not practicing" (Teacher C). Teacher E believed "students give up too quickly....I think sometimes it's their attitude toward math....If you can find a way to increase their willingness to at least try." Following the same school of thought, Teacher G stated the biggest hindrance to students is "the temptation to just give the answer and not worry about the why. Peer pressure. Some students just have a not care attitude...some students don't really understand about dedication...."

### ***Teachers at Low Performing Schools***

Each teacher from low performing schools was initially asked how curriculum decisions were made in their district. Two of the four teachers mentioned the State Standards as the driving force behind the curriculum in their classroom. "Whenever we are testing the kids, that is basically our curriculum, whatever the (state) standards are" (Teacher B). Teacher F, with the assistance of the other math teacher at her school, selected textbooks which they felt covered most of the State Standards. "Because of my course load at a small school, I have tried to pick books that cover the state standards as much as possible. Curriculum decisions are basically left up to myself and the other math teacher" (Teacher F). Teacher H "looks closely at the standards for the Kansas Assessment. I also pay attention to the Kansas Board of Regents program and what is on the ACT test." Teacher D also mentioned the need to prepare students for the ACT test. All of the teachers worked in conjunction with other mathematics teachers at their school and/or the administration to align the curriculum with the State Standards and determine what should be specifically taught in their district. Each teacher had the freedom to determine the

content and how it was taught in their individual classrooms. “We have three different people teaching math at the high school level...I make my own decisions about what I teach” (Teacher H).

The second question of the interview asked teachers to describe a typical day. Only one of the four teachers (G) begins the class by answering questions over the homework or previous day’s lesson. Two of the four teachers from low performing schools had students grade their own papers at the beginning of class. Each teacher reportedly spends 15-25 minutes on lecture followed by time for the students to begin the homework. Two of the four teachers require students take notes during the lecture. The teachers were not very articulate when describing a typical day as they felt the observation illustrated a typical day.

Next, teachers were asked the approach they would use to teach a lesson on slope. Two of the four teachers would begin the lesson on slope through some applications such as the steepness of the slope on a mountain or the grade of a road. Two would begin by graphing the lines on paper and looking at the different slopes. Teacher H then takes the real life examples and the lines on the graph paper and relates it to rate of change while Teacher B tries to show the students all the different approaches required by the state. Only Teacher D, from a low performing school, said that he would begin with the definition of slope, show some examples using the definition, and then eventually try to relate it to the real world.

The fourth question of the interview asked teachers how they determine if students are progressing in math and what changes are made if it is determined that students are not progressing. Three of the four teachers from low performing schools mentioned classroom observation as the primary method of monitoring student progress. All comments were similar to the following given by Teacher D: “by feedback and what they answer back in class gives me a good idea of where they are.” Teacher B mentioned the use of white boards as a tool for students to use when solving examples in class that allowed the teacher to easily see which students were having difficulties. Teacher F states that she watches the homework and test scores very closely. “If the homework scores are not very good, we will spend a day doing a worksheet over the material. I can change the speed of coverage or take extra days to work on the topic.” Teacher D doesn’t “care much about grades. I am more concerned with what they are doing and that they learn something...I work with them if they are not progressing. You just take the kids you get and you do the best you can and help them to the best of your ability.”

Although all teachers wanted the students to learn the material, success on the Kansas State Mathematics Assessment was a concern for each teacher. Two of the four schools had taken drastic measures to improve scores on the Kansas Math Assessment during 2005-2006 or 2006-2007. Teacher B examined all testing indicators to ensure lessons were covered for each indicator. The indicators from the four mathematics standards were then tested throughout the year instead of chapter tests. In addition, from January to March, sophomores spent twenty minutes per day during AR (Accelerated Reader) practicing test questions for the state assessments. According to the KSDE website, this high school achieved building wide Standard of Excellence in mathematics in 2006; however, the tests used for the Kansas Mathematics Assessment also changed in 2006. None of the low performing high schools met Standard of Excellence in 2006 (KSDE, 2006).

Students from Teacher D's school previously spent one to two weeks practicing before state assessments. Sophomores not enrolled in geometry did not receive the additional practice; however, students not required to take the assessment but enrolled in geometry, were forced to practice for the assessment. Currently, a new class named Standards Math has been implemented to better prepare students for the state assessment. Eventually all sophomores will be required to take this class concurrently with geometry. The class was designed to focus on test taking strategies and practice content specifically covered by the state assessments.

Teacher F worked to cover the material throughout the year by teaching the state standards and used a text that covered these standards. Teacher H had spent a great deal of time becoming familiar with the Standards and benchmarks as well as marking them in the lesson plans. By knowing what is on the test and then working with that material throughout the year to be sure the students can do those types of problems is the best way to prepare students according to Teacher H.

The sixth question of the interview asked teachers to reflect on what attributes to the success of students in mathematics class. Teachers D and F both felt strongly about student's work ethic. Teacher F stated, "If a student is willing to work hard and put out some effort, I find that they will succeed. It helps when parents are actively involved, but it comes down to the student's attitude and how they approach the class." Teachers B and H both believed providing students the opportunity to ask questions and get help would determine student's level of success.

In contrast, the final question asked teachers to reflect on what hinders the success of students in the mathematics classroom. Teachers D and F both felt strongly that the lack of work ethic was the biggest deterrent to student success. According to Teacher F “a student who has no work ethic and is not willing to put out any effort, is the student who will not succeed.” Teacher D felt that students use the changing family environment as an excuse for not succeeding however “kids shouldn’t do that. They can still be successful.” Teacher B felt that her own leniency might cause students to be unsuccessful. “I know I might almost work with them too much and not be strict enough on some things. I think I might hinder them.” She also believed “...the focus on the standards has helped the lower kids but I think we have left the upper kids.” Teacher B and H both felt the lack of opportunities available for the students in the small school is the biggest deterrent to success. Teacher H said “...I think that is a bad thing about a small school. We don’t have the ability or the resources or the man power to teach some of the higher level math...I think our kids even from this school that go to K-State or KU show up with a disadvantage even if they had every top math class in our school versus every top math class in a school like Hays.” The students at Teacher B’s school had the opportunity to take Calculus and Trigonometry but “I look for the day when one of those is cut because we need somebody else somewhere else.”

### ***Comparison of Matched Pairs***

#### ***Teacher A and Teacher B***

Both teachers reported the state standards have a major influence on the curriculum decisions that are made in the two districts. Teacher A reported heavy reliance on the textbook for day to day curriculum decisions to alleviate pressures from teaching six different classes per day. When asked what approach they would use to teach a lesson on slope, the responses were somewhat varied. Teacher A, from the high performing school, would begin with a “situation...even some of the patterns we did today and graph them and look what is happening.” In contrast, Teacher B would approach it from an algebraic standpoint, use all the methods the state wants the students to see, and then introduce a real world application towards the end of the lesson.

Teachers A and B both suggested using student feedback and classroom observation as the primary method of determining students progress. Both schools used class time immediately

before the state assessments to better prepare the students. Teacher B aligned the content for the year with the testing indicators provided by the state. Then, for the three months before the state assessments, students spent twenty minutes per day reviewing state assessment questions. Teacher A tries to cover the material on the state assessments throughout the year. Students took the practice assessment online and worked through practice worksheets for two to three days before the assessment date.

Teacher A and B also had different views on what aids and hinders the success of students. Teacher B placed most of the responsibility for student success and failure on the teacher. According to this teacher, the interaction between teacher and student and teacher and content aids the students achieving success in mathematics. In addition, the standards have impacted the success of some students according to Teacher B. “The focus on the standards has helped the lower kids but I think we have left the upper kids...” Teacher A believes the rural school environment is key to the success and failure of students. Students in small, rural schools do not receive as many opportunities as their urban counterparts, but they do receive more individual attention from their teachers than they would at an urban school.

### ***Teacher C and Teacher D***

Teacher C and D both made curriculum decisions as a part of a committee focusing on standards and benchmarks. The textbook, which has been used for five to six years, was chosen to meet the standards and benchmarks in Teacher C’s school. Teacher D focused on streamlining students’ enrollment in courses. Ideally, all sophomores would take geometry so that all can be prepared for the state assessment at the same time.

Both teachers took a similar approach to a lesson on slope, beginning with the definition of slope, rise over run, some examples, and then real world application. Teacher C gave quizzes to assess student progress while Teacher D relied on student feedback during the class. There was a stark contrast in the methods used by each school to prepare for the state assessments. Teacher C focused on content all year long with intensive review one week before the test. Standards Math, a new class at Teacher D’s school, was being implemented to help students prepare for the state assessments in addition to their other math courses. In previous years, students in geometry would practice a week or two before the assessments in order to be better prepared, while students in other classes received no additional preparation.



There was little difference in these two teachers' philosophies on student success. Both believed that a student's work ethic and effort put forth in doing the homework and understanding the material is critical to their success or failure in mathematics class.

### ***Teacher E and Teacher F***

Similar to the other teachers in the study, both Teacher E and F relied heavily on the text to determine the curriculum. Both school districts worked hard to choose a text that followed the state and district standards. Teacher E chose to spend more time covering those sections from the text which were directly related to the state standards. The class structure for both teachers was similar and both teachers spent time with students before school. While students at Teacher E's school were required to attend school early if they were failing, those students at Teacher F's school were strongly encouraged to come in before school to get extra help as necessary and grade their homework papers before class.

Teacher E taught Algebra II which made her approach to slope slightly different than that of Teacher F. "A quick review of rise over run" and some graphs would be sufficient for those students according to Teacher E. In the Algebra I class, Teacher F would begin with applications, discuss steepness and the effect this has on the values of slope, and finally discuss direction. Teacher E gave daily quizzes to assess student's progress while Teacher F focuses on homework and quizzes to determine student progress.

Preparation for the state assessment is somewhat similar in both schools. While Teacher F relies on the text that covers the state assessments, Teacher E allows the students one day to become accustomed to the computer format. In both schools most of the preparation takes place in class throughout the year. Teacher E places most of the responsibility for student success on the teacher, her approaches to the subject, and availability to provide help. Work ethic is the key to student success according to Teacher F.

### ***Teacher G and Teacher H***

The final matched pair provided the most variance in their responses to the interview questions. Although both teachers used the standards to determine the curriculum for the district and both worked to cover the material on the assessments throughout the year, each had very different approaches to teaching slope and determining if students would be successful. Teacher G, from a high performing school, begins a lesson on slope with the derivation of the formula

and the meaning behind it. Teacher H would begin by finding an application, graphing lines on graph paper, and then discussing how the two are related.

Monitoring homework assignments was the best way for Teacher G to assess student's progress. All homework was graded by the teacher, writing comments and correcting students' mistakes keeps him in tune with students' understanding of the material. Teacher H relied on classroom feedback and observation to determine students' progress through the content. Both teachers believed how they approach the class, the students, and the material was a critical component of student success. At Teacher G's school, all students but especially those students labeled "at-risk" had the opportunity to get extra help from the teacher before, during, and after school. Anytime the teacher is not lecturing, students were free to ask questions and get help.

According to Teacher H, the lack of opportunities provided in a small school is one of the main reasons students do not experience mathematical success. Teacher G worried about students just wanting the right answer and not knowing the underlying meaning behind the solution. By getting the right type of help, taking notes, and working through the problems, students are more likely to be successful.

### *Summary of Interview Results*

There appeared to be no consistent differences in how teachers answered the first two questions of the interview. In addition, the comments could not be considered strictly standards-based or strictly traditional. Teachers from both high and low performing schools rely heavily on the state standards and the textbook to determine the curriculum in their mathematics classes. The state standards dictate what content is to be included and what content is discarded. Teacher B comments "that is our curriculum, whatever the standards are." Two of the four teachers in each category grade the homework themselves. Two of the teachers at the high performing schools give completion grades while the other two teachers from low performing schools have the students grade papers together in class. In addition, all teachers plan to spend about 15-20 minutes on whole class lecture with the remaining class time designated to begin homework. Half of the teachers in each category required or placed a great deal of emphasis on the practice of taking notes. One teacher from a low performing school implemented the standards-based practice of students keeping a portfolio to be graded. In addition, only one teacher from a high performing school implemented the standards-based practice of having students keep a

journal/notebook to be graded. It was interesting to note that one teacher from each category implemented group work into the lesson. The practice of whole class lecture every day is aligned with traditional practices; however, all teachers implement the same strategy so this is not a key point for comparison.

The use of standards-based and traditional practices became more evident when comparing the responses from teachers describing their approach to a lesson on slope. Three of the four teachers from high performing schools said they would begin with the derivation of the definition of slope. Each would start with the equation for slope, graph two points on the Cartesian plane, and illustrate rise and run from the graph. Only one of the teachers from a low performing school indicated that he would start the lesson using this same traditional approach. Three teachers from low performing schools and one from a high performing school indicated using a more standards-based approach. Lessons on slope would begin with real-life situations such as the grade of a road in the mountains, by creating a pattern and looking at the change, or by looking for similarities between different graphs of lines and the corresponding equations.

All teachers agreed that the content over which students are assessed should be covered throughout the year as part of the curriculum. Each teacher indicated extra practice was required for the students 2-3 weeks before the assessments were given. Two low performing schools implemented drastic changes into the curriculum to increase test scores while all high performing schools downplayed the amount of practice time given to the students. Three of the four teachers from low performing schools suggested classroom observation and student feedback during the lecture was the best way to determine if students were progressing through the material. Three teachers from high performing schools relied heavily on homework and formal quizzes to determine student progress. One teacher from a low performing school and three of the four teachers from high performing schools requested the students come to them to get help if they did not understand the material. Three of these teachers allowed students to ask questions anytime throughout the day. Teacher comments indicated that much of the responsibility lie with the students. Two teachers from low performing schools and one from a high performing school indicated their first line of defense would be to reteach the material or practice with a worksheet the next class period.

Teachers in each category asserted that a student's personal work ethic would determine his/her level of success. Only one teacher in each category mentioned the students could have a

disadvantage by receiving their education in a rural school. The remaining two teachers, one in each category, felt the teacher had a great deal of control over the student's success.

### ***Observation Results***

The same four matched pairs of teachers were selected to participate in the observation process. All teachers except Teacher F were observed twice following the observation protocol in Appendix E. The researcher completed the observation protocol during the observation time while the class was videotaped. The observations of the teachers at the four high performing schools are described in detail followed by the observations of the teachers at the four low performing schools. The characteristics of a standards-based classroom were established in Table 3.9, 3.10, and 3.11. Each observation was compared to the qualities determined to represent standards-based or nonstandards-based teaching. Observations from high performing schools were then compared to those at low performing schools.

#### ***Teachers at High Performing Schools***

##### ***Teacher A***

Teacher A was observed teaching Algebra I to two different sections of students. The second class period required the teacher to review the material from the previous day due to the misconceptions created by the substitute. Observations from this class period will be used; however, the first class period will be described in depth.

The classroom had sixteen desks in four rows facing the white board at the front of the room. At the back of the room was the teacher's desk with access to a computer and printer. There were numerous signs around the room including the problem solving model adopted by the district, the digits of pi, symbols, properties, operations, and flow maps. In the upper left corner of the front board, the teacher had written the warm-up questions for the class with reminders about what was due below. The class was comprised of five girls and eight boys, two of which were special education students who received assistance from the para-educator in the classroom. In this class of fourteen Caucasian students, there were ten freshmen and four sophomores.

Students took their notebooks from the shelf as they entered the classroom to begin working on the two warm-up problems from the board. These problems focused on the use of

the distributive property to simplify an expression or solve an equation. The teacher was absent the previous day which required some of this initial class time to complete minor housekeeping details. Not all students finished their warm-up problems at the same time; however, whenever finished they took their notebooks back to the shelf.

Seven minutes into the class, Teacher A began the lesson about patterns by making “snowflakes” out of pennies on an overhead projector. As the teacher asked questions about how the pattern grew, what is changing, and what is remaining the same in the snowflake, the students appeared patient with the process and free to comment, answer, and ask questions. The teacher then drew a table or t-chart on the board, asked students to extend the pattern without the use of the pennies, and then pushed them to find the expression or equation for the  $n^{\text{th}}$  term. Students were also asked to find the output value given the input value and vice versa. Example 2 also began with an illustration of the pattern using triangles and toothpicks which was then taught following the same procedure as Example 1.

After the lecture portion of the class, which lasted approximately thirteen minutes, the students were placed in groups of three to four, based on location in the classroom, to complete a worksheet over making and generalizing more patterns. The teacher moved around to help different groups recognize the patterns. The equations for the  $n^{\text{th}}$  terms were never given to the students by the teacher, but hints were given to help them communicate and understand the pattern. Almost all students were on task and appeared comfortable working in groups. It took Group 4 seven minutes to complete the worksheet while the others took about twelve minutes. Each group seemed to be very excited when they were able to write the formula for a pattern. The students liked the challenge and the success that they were able to experience.

As students began to work individually on the homework assignment from the text, the teacher continued to circulate around the room to assist with any questions. During this time, many students had questions about parking in the city since this was one of the patterns described in the text. The teacher took time to explain the context of the problem as many of the students in this rural high school had not experienced parking lots and garages in the larger cities. Students spent the final fifteen minutes of class working on their homework. Class was dismissed by the bell after fifty-one minutes.

### ***Teacher C***

Teacher C was observed teaching Algebra I on two separate occasions. The class structure was very similar in each observation so only the first will be described in detail. There were eleven desks in the room all facing the white board at the front of the room. The teacher's desk, with a computer and printer, was in the front of the room facing the students. There were pictures of cross country teams at the front of the room with the problem solving model on the wall to the right of the students. Eight computers lined the outside of the classroom. The three students in this class consisted of two girls and one boy, all freshmen sitting in the front row during this class.

This class began by the teacher reading the announcements as it was the first class of the day. Students turned in their homework while the teacher reminded them that they would retake a quiz the following day. Two minutes into the class, the teacher put written notes on the overhead projector. As the teacher read and explained the notes and the rule of functions, the students followed along in their textbook. There was space below the projected notes where the teacher wrote additional information to assist the students in understanding the content.

The first example used  $y=x^2$  and  $x=y^2$  to model the differences between functions and non-functions. A graph and table of values were used to model more than one output for certain inputs of the second relation. After six minutes the teacher began to use mappings as another example of relations to help students begin to make the connection to ordered pairs of a function. Throughout this part of the lesson, the teacher asked the students to determine if three to four different relations were functions according to the definition of function given during the notes. Then the Vertical Line Test was introduced as a method to quickly check if a relation is a function. The students struggled with the concept that a parabola is always increasing/decreasing over half of its domain. The parabola does not become vertical as  $x$  approaches positive or negative infinity which allows the function to pass the Vertical Line Test. The students did not have any difficulty understanding that a circle was not a function.

Fifteen minutes into the lecture the teacher began the process of helping the students name functions. In the previous chapter they had looked at linear equations where everything was in the form  $y=mx+b$ . By replacing the  $y$  with  $f(x)$  or  $g(x)$ , only the notation has changed not the meaning or graph of the function. Students were then asked to evaluate the functions at certain values. The lecture ended after thirty-five minutes with the teacher reiterating that

“function notation is just like learning to write your name in cursive. It is still the same name, you are just writing it differently.” The students spent the remaining fifteen minutes of class individually working very quietly on their homework assignment. The class was dismissed by the bell after forty-eight minutes.

### ***Teacher E***

The same lesson was observed as it was taught to two different Algebra II classes on the same day. There were twenty desks arranged in four rows facing the front of this very spacious classroom. White boards were on the front and right walls of the classroom. There was also a gray board that can be used for both chalk and dry erase markers on the right wall. A grading scale was posted in the front of the room, along with an American Flag, the Problem of the Week, the Word of the Week Pyramid, and an overhead projector. The room was decorated with K-State athletic posters as well as one of a TI-83 and a TI-30Xa. On the right wall there was a world map with the names of the foreign exchange students pinned on their respective countries. In the back of the room there was a large black cloth covered in newspaper articles about the students.

This Algebra II class was comprised of seven girls and two boys, all juniors, two of which were of Hispanic origin. All students had access to a TI graphing calculator. Many of the students attended Power Period asking questions about the material covered from the previous day. Power Period is a time scheduled before school for students to come ask questions or get help. Power Period is required of those students receiving a “D” or “F” in any subject. Class began at 8:55 am with the teacher reading the announcements for the day followed by the Pledge of Allegiance.

At 9:00 students were instructed to take out their notes and keep their worksheets from the previous days. Translations were introduced by the teacher moving one step to the left reiterating that changing location does not cause the size and shape to change. The notation  $T_{h,k}$  and the vocabulary pre-image and image were used to describe the translation performed on any given function. The teacher explained that the  $h$  value determines how far to the right or left the function moves while the  $k$  value determines the vertical distance moved. In the first example, the teacher wrote the equation of the image on the board, and then asked the students to determine the equation of the pre-image. Only one half of the students were able to answer the

question, so the teacher attempted to explain it twice more, using the TI calculators to reinforce the ideas the third time.

The teacher did not wait long for the students to explain everything known about the second example which was used to introduce how functions become “skinnier” and “wider.” On the overhead projector, the teacher graphed the first and second examples with only the leading coefficients. This caused some confusion among the students as they did not know why everything except the leading coefficient could be ignored. Initially, the teacher did not try to fix the misconceptions of the students. Eventually those misconceptions were made clear by the end of the lecture and through working on the homework.

Thirteen minutes into the lecture, the teacher began Example 3 which required the students to determine the image when given a pre-image function and the corresponding translation notation. The students were again given minimal wait time to answer the question before the teacher explained the process. Example 4 was presented one minute later with students determining the ordered pair of a point that would be on the image given a pre-image point and a translation. All students appeared to have a solid grasp of this piece of the lecture.

For the final concept in the lecture, the teacher drew the graphs of two parabolas, one with a minimum and one with a maximum. Since each graph is perfectly symmetrical, the equation of this line could easily be determined. The teacher illustrated this by using the dry erase markers as the line of symmetry. All students seemed to understand that  $x = a$  would be the equation of the line of symmetry when  $a$  is the  $x$ -value of the vertex.

At the end of this seventeen-minute lecture, the teacher distributed a worksheet for students to complete and check before leaving class. There was an additional worksheet on the desk in the front of the room to be completed in class or as homework. The teacher walked around helping individuals or groups of students throughout the remainder of the class. Occasionally, Teacher E interrupted to explain a concept that was forgotten during the lecture or if more than one student was having difficulty with a certain question. Students were constantly asking questions about how to do the problems from the worksheet and the teacher was always helping at least one student at all times.

After fifteen minutes, the first student finished the worksheet and checked their answers on the key at the front of the room. All students finished the first worksheet as most were working together to complete each question. The students were very animated as they began to



work on the second worksheet for the last ten minutes of class. The fact there were only two days before a major vacation may have affected student's behavior. Class ended after forty-five minutes with the teacher reminding students to finish this worksheet for class the following day.

### ***Teacher G***

Algebra I and Algebra II were observed on the same day. The algebra I class was not typical as the students were reviewing for a test. The lesson from algebra II, covering transformations of graphs, will be the one described in detail.

The classroom had five rows of four chairs all facing the chalkboard at the front of the room. The teacher's desk was also at the front of the room between the student desks and the chalkboard. Around the room were models of catenary curves, pictures of various curves, motivational posters, as well as German vocabulary words. There were chalkboards on three sides of the room with a white board in the middle of the chalkboard at the front of the classroom. An overhead projector was set up to the right of the teacher's desk pointing toward an overhead screen next to the white board. There were two computers to the far right of the room as well as one printer. The class was labeled Algebra II, however a College Algebra text was used throughout the entire year and students receive dual credit. There were eleven juniors (seven girls, four boys) all of Caucasian ethnicity.

Students entered class and sat down as the teacher passed out sticky graph paper to be used for notes. All students opened their notebooks prepared to take notes. The teacher began the lesson with the function  $y=x^2$  reminding students to choose the points -2, -1, 0, 1, 2 for the values of  $x$  in the t-chart to determine the  $y$ -values. The students then plotted the ordered pairs and graphed the parabola by hand. The teacher introduced the function  $y = x^2 + 3$  and went through making the t-chart again while discussing the process of adding three to each  $y$ -value. Then the second function was graphed by hand. The students were questioned as to what had happened to the previous graph and then asked to predict what would happen to the function  $y = x^2 - 2$ . The teacher used the graphing calculator to further illustrate the point. Finally, the teacher generalized the method for determining if there is a vertical shift.

Teacher G wrote the following example on the board  $y = (x + 3)^2$  while asking students to predict how the graph would move. Many of the students predicted the function would move up nine. Following the same procedure, the teacher and students began with a t-chart using

additional negative numbers to again see the symmetry of the parabola. Students graphed the original function ( $y = x^2$ ) and the new function  $y = (x + 3)^2$  on a new sticky graph in their notes while noticing how the graph shifted. Students then predicted the graph of  $y = (x - 2)^2$  would move to the right. The TI-83 was used to again solidify the concept. A generalization was then given for horizontal shifts.

All notes from the lecture were left on the board as the teacher moved around the room to the different chalkboards. The teacher began expanding the pattern to other functions such as cubics which the students drew in the air. Exchanging the absolute value function for the quadratic, the teacher began the same process but with a leading coefficient. Another generalization was then made concerning vertical stretch and vertical shrink. The vocabulary words, horizontal stretch and horizontal shrink were omitted at this point to avoid confusion. The teacher then switched to the square root function to illustrate reflections over the  $x$ -axis.

Forty minutes into the class period, the teacher summarized all of the material from the lecture which was still written on the board. The students then opened their texts to the homework assignment as the teacher discussed one example from each section. As the class progressed through the examples, those students who were previously confused seemed to understand. Students then began to work on their homework assignment for the remaining two minutes of class. More time to finish the assignment was to be given during the next day's class.

### ***Teachers at Low Performing Schools***

#### ***Teacher B***

College Algebra was observed on two separate occasions the first of which covered a lesson on piecewise-defined functions. The second observation involved students reviewing for a test, therefore the first observation will be described in detail. Teacher B was also the part time counselor at the high school which forced College Algebra to be held in the ITV room and reduced the number of courses taught by her at the current time. There were eight tables, each with two chairs facing the front of the classroom. Positioned at the front of the room was a large bunker holding the computers, controls for the ITV equipment, and the Elmo projecting the teacher's lecture notes onto the front wall. One small white board was on the right side of the room. Displayed on the walls, were Spanish phrases and vocabulary words.

There were ten students in the room during this hour. Four girls and five boy were enrolled in College Algebra while the fifth girl uses this hour as a study hall. Some students had access to a scientific calculator but none used a graphing calculator. Teacher B began the lesson by explaining that this lesson is over functions, prepared for the observation. Students were asked to take out a piece of paper to find the equation of a line through two points and evaluate the function at a certain value. These two problems were review over material covered previously in class but were critical for the current lesson. After allowing students to work through the review questions for five minutes, the teacher reviewed the steps required to write the equation of a line on the board. The teacher called on a variety of students throughout these review exercises.

In the past, the teacher chose to begin with the piecewise-defined function for the students to graph. By changing the approach, now a graph is given and students must write the different equations from this. After finishing the review, the teacher passed a graph of a student's trip to and from school for the students to begin understanding the application of piecewise functions. The teacher began by asking students questions about the meaning of each line, slope, and point on the graph in relationship to the trip to and from school. Students labeled the segments ABCDE and wrote the ordered pair for each point on the graph. On a separate sheet of paper, the students worked individually to determine the equation of each line. After finishing the problems at the desk in the front of the room, the teacher walked around the room to check student's progress. Students were given fifteen minutes to finish writing the equations followed by the teacher asking for volunteers to write their work on the white board. Students compared answers on the board and then discussed any discrepancies or questions that they had. The teacher waited for all students to finish so that they could decide on the correct answers together.

After all students finished, the teacher began discussing all examples by using the student's work on the board. Students were then asked to complete a table similar to Table 4.20.

**Table 4.24: Piecewise-defined functions**

Equation of line	x-values $? \leq x \leq ?$	Function Notation

The teacher completed the first line of the table on the overhead while asking students to determine correct values of  $x$  that go in column 2. Students completed the remaining portion of the table. After reviewing all answers together as a class, the teacher described writing a piecewise equation in function notation. All students felt comfortable asking questions but only one student asked why it was important to determine the  $y$ -intercept since it is not graphed. The teacher explained that the information is necessary to get the correct graph and then reviewed the procedures the students completed.

The students were asked to repeat the same process for Example 2, a piecewise-defined function graphed on the board by the teacher. The teacher and students began working individually on writing the equations for approximately ten minutes. The class period was almost over so the teacher wrote the equations on the board for students to check their answers. A discussion over  $x$ -values and different types of inequalities followed. The lesson ended with the teacher explaining that the next lesson should be to find a graph given the equations; however, that will be covered in a few weeks since this was a special lesson. Class ended after fifty minutes with no assignment given.

### ***Teacher D***

Two different Algebra II classes were observed on the same day. Upon entering the room, a bulletin board was covered with schedules, the problem solving model, a calendar, the grading scale, and the math curriculum. There were nine large tables with two chairs at each table facing the front of the classroom. The teacher's desk was at the front of the room with a computer and printer. Bookshelves filled with mathematics textbooks lined the wall on the left side of the classroom. Chalkboards, with example problems for the day's lesson surround three sides of the room. Each Algebra II class was comprised of freshmen and juniors all of Caucasian ethnicity. The first class had six girls and five boys while the second class had nine boys and six girls.

The second Algebra II class was slightly behind the first due to a student presentation on functions and computers. The class period was then used to cover two lessons. Teacher D explained that this was not typical. Students came in and sat down while chatting about various topics. Notebooks were due on this day so students were scrambling to find notes and assignments to complete their notebooks. The teacher began by reviewing the degree and naming of polynomials which was covered during the previous class then transitioned into the

current lesson on laws of exponents. The lecture began by the teacher stressing “if you know this paragraph, you will know everything that you need to know and will not miss exponents.” “In  $b^n$ ,  $b$  is the base,  $n$  is the exponent.  $b^n$  is called a power,  $b$  is used as a factor  $n$  times.  $b^n = b * b * b * \dots * b$  is factored form.  $b^n$  is exponential form.” After reading the definition again and stressing the importance of each piece, the teacher wrote two examples using numerals to illustrate the point. According to the teacher, the students need to know the first twenty numbers squared and the first five numbers cubed. The class recited these together. All students had access to a TI-81 graphing calculator while some had a TI scientific calculator, which the teacher explained how to use in the event that students could not remember the answers to an exponential.

Some students were taking notes at this point in the lesson while others were just sitting and watching and others were sorting through papers to complete their notebooks. The teacher began the next part of the lecture by giving two examples of multiplying two powers together, and then, with the assistance of the students, wrote a generalization of the first law of exponents on the board. Two more examples followed. This pattern continued as the teacher worked through the next two laws of exponents. After all three laws had been established the teacher reviewed them and then moved to the side board to begin working through the examples written on the board.

Only three to four female students were responding at the beginning of the lesson, however more students participated as the lesson progressed. The teacher moved through a variety of examples. While testing students’ understanding, the teacher explained possible pitfalls, different situations, and integrated various mathematics vocabulary into the lesson. At times the teacher would say the incorrect answer or accept a student’s incorrect answer to determine if students were paying attention.

All students were taking notes as the teacher worked through the examples on the side board. The lecture ended after thirty-four minutes with the teacher assigning thirty-eight problems from the text. Students split into three groups to work together to finish the homework. One group consisted of the female students, while the other consisted of all of the male students except one who chose to work by himself. The teacher worked on the computer or graded notebooks at the front of the room while students worked on the assignment. Students asked each other questions as well as some students went to ask the teacher questions. An hour was

allocated for homework; however, some students had to leave thirty minutes early to practice for the Christmas concert. The remaining four students continued to work on the assignment until class was dismissed by the bell after ninety-one minutes.

### ***Teacher F***

Due to time constraints Teacher F was only observed once; however, the teacher reported it was representative of a typical class period. There were many students in the room asking questions over a variety of different subjects more than ten minutes before school actually started. The room had a white board in the front of the classroom with a Cartesian coordinate system on the right side of the board. Facing the front of the room, there were twenty-four small tables set in groups of two in four rows. The walls around the room were empty however there were two bulletin boards containing school information, right triangle and golden ratio quilts, “pumpkin pi,” and the Ten Commandments of Math. The teacher’s desk, with a computer and printer, was on the right side of the room facing the students.

Typically there are 20 students in the class; however, some were absent due to a school function. There were seven boys, one of which was Hispanic, and eight girls present for the lesson on graphing systems of equations in Algebra I. All students were expected to be in the classroom checking their work with the answer key before class begins, although not all accomplished this task. Class began at 8:08 by the teacher asking students to turn in the worksheets that were homework. Students took out notebooks and graph paper to prepare for notes while the teacher took lunch count. The lesson began by students drawing a set of  $x$  and  $y$ -axes and the line  $y = 2x + 3$  on the graph paper using any method. The teacher walked around the room to help students recall how to graph a line. The line was graphed on the white board by the teacher to allow students to check their work. Students graphed  $y = 2x - 1$  on the same axis. After graphing the second line on the board, students recognized the lines were parallel “because of the  $2x$ .” The teacher repeatedly corrected the students by telling them that only the 2 determined the slope. Students were then required to write the generalization that parallel lines have the same slope in their notes.

On the other side of the graph paper, students were asked to graph a new axis and the lines  $y = 3x + 2$  and  $y = -\frac{1}{3}x - 1$ . All students had access to a straightedge to draw the lines as well as a TI-30xsa (which was not required for this lesson). The teacher discussed the negative

slope on the second equation, how the graphs should look, and the intersection of the two lines. After discussing two additional examples, students were asked to determine the requirements for two lines to be perpendicular by looking at their equations or graphs. Students then wrote the second generalization, “perpendicular lines have opposite reciprocal slopes,” in their notes.

The teacher then extended the problem by giving the students the equation of a line in standard form and asking how to put the equation in slope intercept form, how to identify the slope, and the slope that is parallel and perpendicular to the original line. Students practiced writing the equations of the lines that are both parallel and perpendicular to the original line through given points. The teacher provided many opportunities throughout this process for students to ask questions as well as checked their comprehension through a constant dialogue. The final example forced students to identify the importance of the y-intercept when writing an equation. The students were given an equation of a line and then asked to write the equation of line parallel through a given y-intercept.

At the end of the lesson, the teacher reviewed the definitions of the vocabulary covered in class as well as how those concepts are applied. The assignment was given from the book and the students began working through the problems. Some students continued grading worksheets from the beginning of class. The teacher spent the last twenty minutes of class helping students as they worked on their homework in groups or individually. The teacher was very patient while explaining the concepts that were covered in lecture to many of the students individually. Although the teacher appeared to be the keeper of information, it is evident through the discussion that students were to take this information and store it in their “toolboxes” to be used at a later time. The class was dismissed after fifty-five minute with instructions that the assignment is due in class the following day, but help will be available before school if it is needed.

### ***Teacher H***

Two consecutive sections of Algebra II learning about systems of equations were observed. The room was filled with ten small tables, each with two chairs, facing the front of the room. A large teacher’s desk and filing cabinets were placed between the tables and white board. The teacher was in this room for the two classes observed, however teaches in different classrooms throughout the day. Surrounding the ten tables are eighteen computers used for business classes. Most of the materials covering the walls were for business classes including

information concerning credit cards, banks, checking, and the Stock Market. There were two math posters on the wall at the front of the room as well as the problem solving models and information on the distance formula and exponents. The left wall of the classroom had windows to the adjoining classroom; however, this did not appear to be a distraction to teachers or students. The first class had seven girls and ten boys, two of which were Latino. The second class had four girls and four boys all of Caucasian ethnicity. The material covered and the method it was covered in each class was very similar. Adjustments were made in the second class to avoid pitfalls discovered during the first.

Each table had rulers, graph paper, and a TI-83 or TI-81 graphing calculator on it as students entered the classroom and put their books on the tables. Students were asked to open their texts while discussing the definition of systems of equations. In previous classes, students learned about linear equations and three different situations that can occur when there is a system of linear equations. The students appeared to feel very comfortable in the class by answering and asking questions as the lesson progressed.

On the board, the teacher had the linear equations needed for the problem used in the current lecture. One student read the question aloud from the text. The teacher called on various students to determine what the different variables represented. Students then began the process of graphing the equations on their graph paper by deciding which variable would lie on the  $x$ -axis and how to effectively graph a slope of three tenths. The students appeared to have difficulty graphing the linear equations by hand because the most appropriate scale did not fit well on the graph paper. This was adjusted to be more effective during the second class period. Students then graphed the line using the graphing calculator. A discussion concerning scale again ensued as the students asked how to set the window on the calculator and how to accommodate the  $y$ -values in thousands. Students then used the calculator to determine the intersection point of the two lines. The teacher then led a discussion as to the meaning of the slopes of the lines, the point of intersection, and how students can interpret profit, revenue, and cost from the graph. Students were asked to determine the results if twenty pounds of steel were needed instead of the conditions given in the problem. As the students began to calculate the answer, the teacher walked around the room to assist different students throughout this process. After two minutes, the teacher brought everyone back together to discuss more applications of this specific problem. All students were paying attention and asking questions at this point in the lesson. The lecture



ended with the teacher explaining when students might see these types of problems again in the future.

A worksheet was given to the students to practice the various methods for finding the solution to systems of linear equations. The teacher wrote specific instructions on the board as to which method to use for the different questions. Students were given approximately twenty minutes to work on the worksheet while the teacher circled around the room helping individual students. The teacher encouraged the students to practice and check answers by using the graphing calculator. The worksheet was to be due the following class period; however, some students did finish in class. Students began packing their belongings. Class was dismissed with the bell after fifty-one minutes.

### ***Comparison of Matched Pairs***

#### ***Teacher A and Teacher B***

The lesson taught by Teacher A was an introduction to functions through the use of patterns created using pennies to form “snowflakes” and toothpicks to form triangles. Teacher A led the students on a guided discovery to extend, graph, and generalize various patterns through the use of tables and variable notation. Students were encouraged to work with functions in these various forms to find the output value if given an input value and vice versa. Through the additional homework problems and worksheet problems, students were able to look at a variety of patterns in various contexts. By having students extend patterns to large numbers, the teacher helped students see the need for symbolic algebra. Teacher A discussed the rates of change associated with each pattern and how that value can be used in writing the equation used to model the function.

Teacher B’s lesson on piecewise-defined functions focused specifically on writing equations of lines. The teacher began with students reviewing how to write the equation of a line given two points and evaluating a function at a specific value. Then through the use of a graph representing a trip to and from school, the students wrote the equations of lines associated with each leg of the trip. Students were given opportunities to confer with each other and the teacher to about methods used to determine the equation of the line etc. Students compared answers on the board and reasoned through any possible discrepancies or questions. The graph was used as

the context of the lesson but not connections were made between slope, ordered pairs, and the trip. Table 4.25 illustrates specific practices observed by as the teacher covered the content.

**Table 4.25: Observed Practices of Teachers A and B**

	Teacher A: High Performing School	Teacher B: Low Performing School
Lesson	Patterning Linear Equations	Piecewise-defined Functions
Problem Solving	Students made patterns, predicted, and made generalizations	
Reasoning and Proof	Moved to the level of abstraction	
Communication	Student/Teacher Communication Student/Student Communication in groups Journals	Student/Teacher Communication
Connections	Took advantage of teachable moments i.e. parking in a city as a type of function Reviewed previous material	Used “real-world” as motivation Reviewed previous material
Representations	Table, Function Notation, Verbal, Graph	Graph, Function Notation
Traditional	Lecture	Lecture, work at board

Teacher A had more classroom interruptions by outsiders as there were two announcements on the intercom and the principal came to the classroom. The students provided more interruptions in Teacher B’s classroom by asking to get drinks or choosing not to participate in the review problems.

Although College Algebra was offered in the ITV room with access to technology, the students from Teacher B’s school did not have access to graphing calculators. Teacher A’s students had access to graphing calculators. Teacher A used at least three different representations of the material while Teacher B focused on the symbolic process of writing the equation of a line.

### ***Teacher C and Teacher D***

Teacher C was observed teaching two separate lessons covering different aspects of the concepts of functions. The lesson began with the teacher giving various representations of functions and non-functions (relations) to model the differences between the two and help students gain a deeper understanding of the definition of functions. The teacher used mappings, ordered pairs, and graphs to have the students apply the definition of function. Students were asked to justify and explain their reasoning when deciding if a relation given by the teacher was a function. After gaining an understanding of the definition of function, the teacher helped the students connect this new material to the previously learned content concerning lines and linear equations.

The second lesson observed began with the teacher generalizing how to solve equations and inequalities involving absolute value. Students were to remember that there are always two solutions which will be written in one of three ways depending on the inequality or equal sign. If a particular problem does not match one of the three given patterns, algebraic manipulation must take place first. Symbolic manipulation and graphs were illustrated as two methods which can be used to solving these equations and inequalities. After several examples on the board, the teacher moved into practical application of absolute value problems. After working one application of an inequality on the board the teacher discussed margin of error and the use of computers to set these specifications.

Teacher D was observed teaching two separate lessons covering exponents. Each lesson began with a review of the previous lesson covering characteristics of polynomials. Students had added and subtracted polynomials in the previous lesson but needed this introduction to exponents before they could learn to multiply and divide polynomials. The teacher began with the following definition: "In  $b^n$ ,  $b$  is the base,  $n$  is the exponents.  $b^n$  is called a power and  $b$  is used as a factor  $n$  times.  $b^n = b * b * b * \dots * b =$  factored form and  $b^n$  is exponential form." Students were encouraged to memorize this definition in order to be successful with exponents. Teacher D then proceeded to work through the definition using examples where the base was an integer instead of a variable. After having students recite the squares of the first twenty numbers, cubes, and fourth powers of the first five numbers, the teacher explains the carat key on the calculator. The teacher then introduced the rules of exponents through examples including those when the base of the exponent was a variable.

Before the lesson, the teacher had about twenty examples written on the board. After establishing the rules of exponents, the teacher had students work through the examples with him. Throughout the lesson, vocabulary words such as monomial, polynomial, and distributive property as well as the definition and rules of exponents were constantly repeated by the teacher to the students. Throughout the lesson, the teacher challenges the students to defend their reasoning by questioning their answers to the different questions. The examples continued to get more difficult as the lesson progressed. Table 4.26 illustrates practices observed while teachers covered the content.

**Table 4.26: Observed Practices of Teachers C and D**

	Teacher C: High Performing School	Teacher D: Low Performing School
Lesson	Introduction of Function Notation	Power Rules
Problem Solving		
Reasoning and Proof		
Communication	Teacher/Student	Teacher/Student Student/Student
Connections	Real world application at end of lesson Connections to learning to write linear equations	
Representations	Functions, Table, Mappings, Graph	Function Notation
Traditional	Lecture	Lecture

The number of students in each of the classes was a major difference between these two schools as Teacher C only had three students compared with Teacher D's eleven and fifteen. This was supported by each teacher's response to the survey. Teacher D's school was on block scheduling while Teacher C taught using a traditional schedule. The third difference was the age of students in the classroom. Teacher C taught all freshmen in each of the algebra classes while Teacher D had a mix of freshmen and juniors in each class. Teacher D had more interaction with the students throughout the lecture but also had a greater percentage of students not paying

attention throughout the lesson. Teacher C was more available to help students while they were working on homework.

Both teachers had similar approaches to the mathematics by focusing on rules and definitions. Teacher D had students memorize math facts, a traditional practice, and collect their work in portfolios, a standard-based practice. Those students in Teacher D's school had access to a graphing calculator while students in Teacher C's school did not. This may have been because Teacher C was observed in an Algebra I course.

### ***Teacher E and Teacher F***

The content of the lessons observed by Teacher E was an introduction to translations of parabolas. The lesson began with the teacher describing a translation of herself as she moved around the room. After this brief introduction, Teacher E wrote the notation for translations and the vertex form of a parabola  $[y - k = a(x - h)^2]$  with an explanation that the parabola moves  $h$  units to the right/left and  $k$  units up/down. The teacher focused mostly on the function and translation notation for numerous examples of slightly different parabolas to illustrate the various possibilities of translations. She then moved to a graphical representation to assist the students in noticing how the vertex moves and the relationship of the motion to the equation. The examples appeared to get increasingly more difficult. Students were eventually pushed to make generalizations about the function by reasoning without the graph or the function notation.

The content observed by Teacher F included writing the equations of lines that are parallel and perpendicular to each other. The lesson began by the teacher having students graph a line using any method they chose. This part of the lesson should have been review as students had worked with linear equations previously; however, students appeared to struggle with this concept. After students have struggled with the concept the teacher draws the graph on the board for the students to check their work. Then she gives them an equation of a second line to graph. The teacher then leads the student in a guided discussion as to what students notice about the two graphs and the equations. Together, they make a generalization of how to determine if lines are parallel by looking at the equation or the graph.

The process then repeats with a new set of lines. The teacher again leads a discussion about the graph of the two lines, the equations, and the relationship between the slopes of the two lines. Students again make a generalization and write the information in their notes. The teacher

gives students equations of lines in slope-intercept, standard, and point-slope form. Students work to write their own equations of parallel and perpendicular lines using various information given by the teacher. Table 4.23 illustrates observed practices by Teachers E and F while covering the respective content.

**Table 4.27: Observed Practices of Teachers E and F**

	Teacher E: High Performing School	Teacher F: Low Performing School
Lesson	Translation of Functions	Parallel and Perpendicular Lines
Problem Solving		
Reasoning and Proof	Moved to abstraction Students made predictions and generalizations	Students made predictions and generalizations
Communication	Teacher/Student Student/Student Students were taking notes	Teacher/Student Student/Student Students were taking notes Questioning by teacher
Connections	Used multiple approaches Reviewed previous material	
Representations	Function, Graph, Translation Notation, Technology	Function, Graph

Both teachers had students in the classroom getting help before class. Teacher E began the lecture by giving the students the rules and definitions, examples, followed by the students practicing on their own. Teacher F began with the students doing the work, looking for rules and patterns as the lesson developed. The teacher would then write the formal rules on the board for students to write in their notes. After working through numerous examples on the board, students continued to have many questions on the homework. There appeared to be a lack of transfer between the work during the lecture and the homework problems. Teacher E experienced the same lack of transfer with students. The lecture was comprised of few examples over a variety of concepts.

While students were working on their worksheets or homework, both teachers were very accessible for students to ask questions and get help. Teacher E repeatedly interrupted the students to remind them about different elements of each problem. Teacher F assigned nearly sixty homework problems while Teacher E assigned two worksheets of nearly ten questions each. Both classrooms had access to appropriate technology; students in Teacher E's class had access to graphing calculators while Teacher F's students had access to TI-30xsa.

### ***Teacher G and Teacher H***

Teacher G was also observed teaching a lesson on translations but extended the lesson to include all functions. The lesson began with by the teacher reminding students the recommended x-values to get a representative graph as had been discussed in the previous lesson. He then began by making a t-chart of the function  $y = x^2$ . Throughout the numerous examples presented throughout the lesson, each function was presented using a t-chart, function notation, and graph of both the original function and the translated function. Teacher E also chose to have students view many of the functions on the TI graphing calculator. The lesson was designed in a very systematic manner as the teacher would do an example of a vertical shift up followed by students predicting how to obtain a vertical shift down. This process repeated for horizontal shifts, vertical stretches, and vertical shrinks.

Teacher H's lesson used a problem to illustrate an application to solving systems of linear equations. Students had already learned to solve systems using substitution, elimination, and graphical methods. After one student read the word problem from the text aloud, all students began to try and graph the given equations. Students must decide how to label the axes and determine an appropriate scale for each axis. Together the teachers and students discussed scale but the graphs created by hand were not working as they had chosen an incorrect scale. Eventually all students moved to using a graphing calculator to determine an appropriate graph. Students had some difficulty setting an appropriate window. Students began to find the point of intersection using the technology.

After students had found the point of intersection, the teacher drew the graph on the board. Leading the discussion, Teacher H tried to help the students understand the meaning of the graph, what the input and output represented in terms of the application, and the relationships between cost, revenue, profit, and the lines and points which were graphed. After discussing this one problem, the students began solving various systems of equations using the three

different methods. None of the problems on the worksheet are applied or similar to the one used in the lesson. Table 4.24 illustrates observed practices by Teachers G and H as they taught their respective lessons.

**Table 4.28: Observed Practices of Teachers G and H**

	Teacher G: High Performing School	Teacher H: Low Performing School
Lesson	Translation of Functions	Composition of Functions
Problem Solving		
Reasoning and Proof	Students made predictions and generalizations	
Communication	Teacher/Student Students were taking notes	Teacher/Student Student/Student
Connections	Referenced many connections to algebra	Real world application used as motivation
Representations	Table, Graph, Function Notation, Technology	Function Notation, Graph, Technology

Throughout the lectures, Teacher G was more focused on rules; definitions, multiple representations, and helping students write generalizations. Student communication was kept to a minimum. In contrast, Teacher H focused on applications and the relevance of the algebraic concepts being studied. Students were talking with each other and the teacher throughout the lesson. Teacher G strongly encouraged students to take thorough notes while Teacher H did not. The lesson presented by Teacher G was very organized and focused while the lesson presented by Teacher H tended to be more scattered as students had difficulties graphing lines by hand and students chatted amongst themselves at different times throughout the lessons. Both classrooms had access to graphing calculators.

### ***Summary of Observations***

The characteristics of a standards-based classroom were established in Table 3.9, 3.10, and 3.11. Each observation was compared to the qualities determined to represent standards-



based or nonstandards-based teaching. Observations from high performing schools were then compared to those at low performing schools.

None of the eight teachers observed provided opportunities for problem-based learning. Teachers A, from a high performing school, emphasized student exploration instead of teacher explanation more than any of the other teachers. Two teachers from high performing and two from low performing schools began the lesson with two or three examples of the concept to be covered. Students were then asked to generalize a pattern from the examples. This practice provided opportunities for students to look at various patterns and use abstraction when appropriate, which is recommended in the NCTM Algebraic Content Standards. The remaining teachers explained the pattern to be used by the students to complete the homework; which is considered a traditional practice.

Student/teacher communication was limited primarily to simple recall questions throughout the lecture. All teachers were accepting of student's questions throughout the class, however only Teacher A, from high performing school, organized opportunities for the students to communicate with each other. Teachers C and G, from high performing schools, focused on students working quietly by themselves to gain a better understanding of the material. Teachers B, D, F, and H from low performing schools, and Teacher E from a high performing school did not discourage students communicating with each other to gain understanding; however, none of these teachers used collaborative learning as an instructional technique.

In addition, teacher/student communication was part of the informal assessment process in each classroom. All teachers kept a running dialogue with the students by asking questions about vocabulary, conjectures, patterns, and laws used throughout the lesson. Two teachers from high performing schools, Teachers A and E, allowed students' questions to direct parts of the lesson. The students questioned the applications, not the mathematics, but the teachers took advantage of these teachable moments.

The use of technology is encouraged throughout the NCTM Standards. Three of the four teachers from high performing schools, Teachers A, E, and G, as well as two of the four teachers from low performing schools, Teachers D and H, implemented the use of graphing calculators into the lesson. These teachers encouraged the use of technology during the lecture and homework as a method for students to check answers.

Three of the four teachers from each category referred to previously learned material throughout the lecture to remind students about the content covered the previous class period, only Teachers E and B did not. Three teachers, one from a high performing school and two from low performing schools, tried to connect the mathematics content to other subjects or real-life examples. Teacher A, from a high performing school, willingly discussed the pattern that can develop when one chooses to pay for parking in a larger city. The context of the activity chosen by Teacher B from a low performing school allowed students to think about a trip to and from school instead of merely the graph of five lines on a page. Teacher H chose examples connecting the solutions to systems of equations to the financial world.

All teachers from high performing schools were proficient at explaining the mathematical content using multiple representations of the content. Teachers A and G (high performing school) used a table of values, a graph, and function notation in each of the examples presented during the lecture. Teacher C, also from a high performing school, explained functions as a mapping, ordered pairs, equation, and a graph. While Teacher E had a significantly different approach to transformations than Teacher G, both from high performing schools, function notation, transformation notation, and graphs were all used as ways to illustrate the mathematical content.

Teachers B, F, and H, all from low performing schools, had the students graph equations to be used throughout the lesson. Teacher F emphasized that both representations of the function could be used to determine if two lines were parallel or perpendicular. However, Teacher B and H focused on one representation of the function for the duration of the lesson. Using, integrating, and requiring the students to use multiple representations of the same function is a standards-based practice encouraged throughout the NCTM Standards document, while focusing on one representation is consistent with traditional practices.

Almost all teachers provided opportunities for students to be active participants in the learning process. Teachers D and F, from low performing schools, and Teachers E and G, from high performing schools, all had students taking notes throughout the lecture. Not all teachers graded students notes, but all had set the expectation in the classroom that notes should be taken. Taking notes may not be considered a standards-based practice but all students were actively involved in the learning process which is an important component of standards-based learning. Teachers A, from a high performing school, and B and H, from low performing schools, had

created an activity or context for the students to use to develop the mathematics. This is considered a more standards-based practice by providing applications to keep the students motivated.

All eight teachers relied on whole group lecture to teach the material. Although Teacher A tried to implement more problem-based learning into the lecture, all students were working on the one problem led by the teacher. All teachers also relied on worksheets and large assignments from the textbook for students to practice the concepts learned in the lecture. Only Teacher D, from a low performing school, had students memorize math facts without any context. The students recited the first twenty numbers squared and the first five numbers cubed together.

### ***Artifact Results***

The lesson plans and materials used in the classroom give insight into the teacher's approach to mathematics. The eight teachers were asked to share as much as possible from the list of artifacts in Appendix F. Two of the eight teachers (one from each category) chose not to submit any artifacts; yet a wide variety of information was received from the remaining six teachers. All artifacts received from teachers at high and low performing schools were coded and evaluated separately. Comparisons between teachers at high and low performing schools were then made to assist in answering the initial research questions. Question 7 of the survey asked teachers to list the mathematics texts used in the classroom. As most teachers tended to rely heavily on the textbooks, Algebra I and II texts for matched districts were compared.

The data from artifacts of the teachers at the four high performing schools are described in detail followed by the data from the teachers at the four low performing schools. The data from matched pairs is compared and contrasted followed by an overall comparison between those teachers from high and low performing schools to answer the initial research questions.

### ***Teachers at High Performing Schools***

Two of the four high performing schools used the Algebra II text from the University of Chicago which combines both traditional and standards-based methods. The other two schools used a more traditional text. A more indepth analysis of the texts is presented in the comparison of artifacts from matched pairs.

The lesson plans from Teachers C and G were presented in a traditional format focused on skill development. Teacher C started with a simple example of the concept to be covered.

Each successive example was more difficult than the previous with a variety of examples covering all possible problem types. Teacher C also had all rules written in the lesson plans to be shared with the students. Each lesson ended with a problem applying the material covered and an assignment of about fifteen problems from the text.

Teacher G's lesson plans were similar in format. The students were shown several examples and then predicted the results for similar problems. Throughout this directed discovery lesson, the teacher and students worked together to write the rules and formulas. Teacher G planned to have the students visualize a variety of functions using multiple representations. The weekly lesson plans given by Teacher G included the topic to be covered and the homework problems to be assigned to the students.

Teachers C, E, and G each submitted worksheets and tests from the chapter covered at the time of the observation. Teacher C's quizzes were five questions chosen from the larger quizzes provided by the textbook company. All questions on the quizzes were skill driven. Students were required to work with different representations of linear functions as well as make connects among the different notations. Teacher E used Lesson Master Worksheets and Quizzes provided with the UCSMP Advanced Algebra textbook published by Scott, Foresman and Company. Questions on the worksheets consisted of definitions; many were skill-based problems, and some required the students to have a deeper understanding of the process and skills used while making connections to the various representations. Teacher G submitted no worksheets or quizzes.

The test submitted by Teacher C consisted of problems chosen from the tests provided with the textbook. Eighty-five percent of the questions on the test were strictly symbolic manipulation or traditional skill-based. Two of the twenty questions required yes or no answers but no reasoning or explanation was required. The remaining problem could be considered application; however it did not require more than two steps to solve while none of the questions would be considered problem solving. Teacher E provided a typed test not from the text. Eight of the fourteen questions were skill-based problems. Three test questions were used to determine students' understanding of the material by asking questions that did not require any symbolic manipulation. The remaining three questions could be considered application but not problem solving, requiring students to interpret a graph or manipulate an equation depending on the students' preferred method. Teacher G provided a handwritten test for both College Algebra and

Algebra I. At least one question on each test asked students to define terms or properties. Forty-three percent of questions on the College Algebra test and 56% of those on the Algebra I test were skill-based requiring students to solve or graph an equation or evaluate a function at a given value. Students were required to have an understanding of the different representations and the connections between the different characteristics of the functions. The remaining questions on the College Algebra test consisted of two problems requiring simple yes or no answers without explanation followed by one applied problem. This test also included two bonus questions, one of which required the students to understand notation and be able to think more abstractly. The remaining six problems on the Algebra I test were applied problems requiring the students to set up and solve equations. Based on the above evidence, these tests were primarily skill based in nature yet students were required to make connections even if the problem did not explicitly call for it. In addition, students were required to be familiar with a variety of representations of the different functions.

### ***Teachers at Low Performing Schools***

None of the low performing schools used a strictly standards-based textbook such as those supported through National Science Foundation (NSF) funds. All texts would be considered more traditional in nature. One of the four schools used the Saxon series, which is not considered a standards-based textbook. A more indepth analysis of the texts is presented in the comparison of artifacts from matched pairs.

Teacher H submitted a set of lesson plans with the corresponding standard and benchmark labeled on each lesson. Although Teacher H did not report having students collect their best work in a portfolio, the teacher did collect and file homework assignments which were submitted in the collection of artifacts. Students were then required to submit a notebook of homework and projects to their parents for review. Teacher H was the only one to submit a problem-based lesson. The lesson, “Bungee Barbie and Kamikaze Ken”, was designed for students to work in teams to gather and graph data, determine the line of best fit, and make predictions from the model. Three to four class periods were designated for this activity early in the year. Teacher H mentioned the students enjoying these types of activities and lessons, but the activities require a great deal of class time that is in short supply.

Teacher B, F, and H all submitted worksheets and tests as part of their artifacts. The graph of the “Trip To and From School” with solutions was submitted by Teacher B. This lesson

covering piece-wise defined functions had the potential to help students make connections and use reasoning skills by giving students some context to interpret slopes, points on the line, and make connections with the inequalities. The students also had practice writing the corresponding equation to the five lines. Teacher F used worksheets called Practice Masters provided with the text by Holt, Rinehart and Winston. All questions on the worksheet were skill based with Worksheet C having more application than the other two. In class observation, students reported liking the worksheets because they “felt they were easier than homework from the text.” Teacher H submitted short, skill-based, hand-written worksheets to be used by the students for extra review.

Two of the three teachers submitted tests that were provided with the textbook. The College Algebra Test, submitted by Teacher B, consisted of eighteen questions, twelve (67%) of which were skill-based. Three word problems, which were very similar to those on the Algebra I test, submitted by Teacher C, were at the end of the test. The remaining two questions required students to discuss the properties of the function and to determine if the equation defined  $y$  as a function of  $x$ . This last problem required no explanation by only requiring a simple yes or no answer. All (100%) of the questions on this test would be considered skill-based without requiring students make connections or justify their answers. The test submitted by Teacher F contained twenty-four questions all of which were skill-based in nature. This test was created by the teacher and was not the one from the text. Teacher H submitted a test which was provided by the Algebra II text from Houghton Mifflin Company with additional questions added to prepare students for the ACT. The test consisted of sixteen skill-based multiple choice questions, two of which required the students to work backwards and show deeper understanding, connections, and reasoning through the process. The four questions at the end were taken from ACT practice tests but covered similar material. This test would also be considered primarily skill-based as all but two questions required students to work in a non-straightforward skill-based manner.

### ***Comparison of Matched Pairs***

#### ***Teacher A and Teacher B***

No artifacts were provided by Teacher A. Teacher B submitted tests and worksheets which were used in the results for teachers at low performing schools; however, no comparison could be made with Teacher A. The textbooks used by each school are compared below.

Teacher A used the University of Chicago Math Project (UCSMP) for algebra, geometry, and statistics/trigonometry. According to the UCSMP web site, UCSMP is considered a combination of standards based and traditional text “emphasizing reading, problem-solving, everyday applications, and the use of calculators, computers, and other technologies.” The text intends to have all students experience mathematics that was once reserved for honors students by eliminating unnecessary review and repetition. The integration of statistics, geometry, discrete math, and probability throughout all courses is one of many key features (UCSMP, 2006). Functions are not introduced until late in the text. Chapter 13 introduces linear, absolute value, polynomial, logarithmic, probability and tangent functions, using all of them to model different phenomena.

Teacher B reported using the Prentice Hall text by Bellman, Bragg, Chapin, et al, *Algebra: Tools for A Changing World*. Functions and their graphs were first introduced in chapter 2 with students collecting and graphing data. Patterns and trends for various families of functions were addressed. The next four chapters focus on linear functions followed by two chapters covering quadratic and exponential functions. The last two chapters of the text cover rational functions and polynomials. A formal review, similar to that of UCSMP, was not available for this text.

### ***Teacher C and Teacher D***

No artifacts were provided by Teacher D. Teacher C submitted classroom notes, tests, and worksheets which were used in the results for teachers at high performing schools however no comparison could be made with Teacher D. The text books used by each school are compared below.

The McDougal Littell text, *Algebra I* by Larson, Boswell, Kanold, and Stiff was used in Teacher C’s school. Representing functions as rules, tables, and graphs are concepts introduced in the first chapter of the text. Chapters 4-7 focus on linear functions and various uses and applications of linear equations. Exponential functions are introduced in chapter 8 followed by polynomials, quadratics and rational functions. The book ends with a short chapter on geometry, probability and statistics.

Teacher D used the McDougal Littell text by Brown, *Algebra II and Trigonometry*. This Algebra II text introduces functions and linear functions in two sections of chapter 3. Although polynomial, quadratic, and rational expressions are examined throughout the remainder of the

text, a function-based approach is not used until chapter 10 which covers exponential and logarithmic functions.

### ***Teacher E and Teacher F***

Each teacher submitted worksheets from the text to be used as review, homework, or extra practice as needed. The majority of the questions asked students to perform symbolic manipulation. The worksheets presented by Teacher E contained mostly skill driven questions. Four questions on one worksheet were attached to an application requiring students to write and use an equation to determine the appropriate results. One question did ask students to explain their reasoning. Four questions on one worksheet given by Teacher F contained an application. Three of these four word problems were strictly symbolic manipulation while the fourth problem asks students to make a generalization based on the previous problems.

Each teacher also submitted a test written by the teacher to be used as an assessment. Teacher E's test also contained many skill driven questions. There were more application problems on the test which followed a pattern similar to those on the worksheet: writing an equation and using the equation and graph to determine appropriate answers. The test submitted by Teacher F was all skill driven and considered very traditional in nature. The application problems did require students to solve two-stop equations.

Each school used the same Holt, Rinehart, and Winston Algebra I text. There was a drastic difference in the philosophies of the textbooks used for Algebra II as Teacher E used the Advanced Algebra from the University of Chicago Math Project and Teacher F used Algebra II from Saxon Math. The Chicago series emphasizes reading, problem-solving, everyday applications, and the use of calculators, computers, and other technologies. While functions are not integrated until late in the text, statistics and discrete mathematics were integrated throughout. Teacher F was the only one of the eight teachers to use the Saxon series, which is considered a highly traditional text. This skill-based series focuses on instruction, practice, and assessment. A spiral approach is implemented into the review by having students continually revisit old material. The Algebra I text begins basic coverage of functions in chapter 4, followed by linear, quadratic, exponential, radical, and rational, throughout the remainder of the text.



### ***Teacher G and Teacher H***

Teacher G and H both submitted copies of their lesson plan books and an exam. In addition, Teacher G submitted a copy of the notes presented in class while Teacher H submitted copies of student work, worksheets, and an activity lesson plan used earlier in the year. The lesson plans were very similar with each teacher writing the name of the lesson and the homework problems to be assigned. Teacher G also mapped each lesson to a standard and benchmark and marked this on the lesson plans.

The tests provided by each teacher were very different. Teacher G provided a handwritten test with a variety of questions including multiple choice, fill in the blank, matching, and solving equations. Students were not required to explain reasoning; however, work was required and the variety of questions forced students to understand the material from multiple perspectives. Teacher H used a test from the text consisting of strictly multiple choice questions. Students were required to show work on some of these questions. There were four additional questions from practice ACT tests attached to the end of the test. All questions were skill driven and very traditional in nature.

Teacher G used Prentice Hall's College Algebra by Sullivan for Algebra II. Chapter's 3, 4, and 5 study linear, quadratic, rational, exponential, logarithmic, and polynomial functions in detail. Each used Houghton Mifflin series, *Algebra and Structure* Book 1 for Algebra I. Linear functions are not introduced in this text until chapter 8 followed by quadratic functions in chapter 12. Teacher H used the Houghton Mifflin series, *Algebra and Trigonometry Structure* Book 2, by Brown, Dolciani, Sorgenrey, and Kane. Linear functions were studied in chapter 3, quadratic functions in chapter 7, followed by exponential and logarithmic functions in chapter 9.

### ***Summary of Artifacts***

Each of the six teachers submitting artifacts primarily used a traditional approach to the questions used on assessments and included applied problems which required one to many steps to reach solution. Teachers from high performing schools included questions that could be standards-based had students been required to explain or discuss the reasoning process used to reach the answer. Only one teacher from a low performing school used questions that required explanation; however this was part of the test provided with the text. All other tests were highly skill-based with one consisting of only multiple choice questions.

The teachers were asked to submit material from the unit in which the lessons were observed which may have limited the materials received by the researcher. Two teachers from low performing schools submitted lessons, “A Trip to and From School” and “Bungee Barbie and Kamikaze Ken”, which held the potential to be primarily standards-based. No other teacher from either category of schools submitted a lesson which would be considered standards-based.

### **Triangulation**

Data was taken from surveys, interviews, observations, and artifacts from the eight teachers in order to more fully answer the research questions. Throughout this section, the survey responses from the eight teachers are triangulated with the data from the remaining three categories. Data from teachers at high performing schools and low performing schools are triangulated separately before comparing data across the categories.

#### ***Teachers at High Performing Schools***

The four teachers representing high performing schools offer a wide variety in the amount of teaching experience and additional training in mathematics education that each had received. One teacher had earned a graduate degree with a concentration in mathematics education. Only one of the remaining teachers from the high performing schools had taken any additional coursework. None of the four schools uses the same text to teach the algebra classes. All report having fewer than fifteen students in each class. The four teachers are aware of the *Principles and Standards* with only two of the four teachers having read them.

The amount of collaboration or group work encouraged by the teachers in these classrooms was reported to be not more than once or twice per month from questions 13, 21, and 32. Data taken from observation supports this result as only one of the four teachers incorporated group work into the observed lesson. As noted in the interviews, Teacher G does not encourage the students to work in groups.

Teachers reported encouraging the use of manipulatives, alternative methods, or multiple representations in problem solving (survey questions 14, 15, 18, 20, and 22) slightly more than once or twice per month. In each of the classrooms observed, manipulatives did not appear to be readily accessible by the students; although students in three of the four classrooms had access to a graphing calculator. Three of the four teachers were observed using multiple representations while teaching the new material. Questions taken from the various assessments presented as

artifacts encouraged students to understand and work with the various representations of functions.

Only one of the four teachers (Teacher A) at high performing schools had students write in a notebook or journal during the observation and reported using this method in the interview. The remaining teachers reported rarely having students write reflections about content learned in class. Students were encouraged to take notes in two of the three remaining classes but were not required to write reflections as part of this process. During the interview, none of the four teachers reported using journals, written reflections, or students' notebooks as a way to determine how students were progressing in mathematics class.

Many of the artifacts received from these four teachers were formal exams and quizzes. Information taken from these assessments helps to triangulate data from questions 29, 30, 38, 39 on the survey. All tests had questions requiring students to work problems, show work, and demonstrate understanding of the concepts covered. While there were no multiple choice questions on any of the tests presented by teachers from high performing schools, Teacher G used a minimal amount of matching and fill in the blank questions. This same teacher also asked students to define terms and properties. Each exam had questions that held the potential for students to write explanations and descriptions yet none were written to explicitly require this of the students. In order to successfully answer the questions, students must be able to make connections among the various representations. While only observed in one classroom, teachers reported having students work problems at the board more than once or twice a month. Teacher A mentioned the use of whiteboards in the interview as another method of informal assessment.

Teachers reported explaining new mathematics content to the entire class almost daily (question 33), but only use a problem solving task for students to discover the concept before more formal explanation once or twice per month (question 34). In each of the classrooms observed, teachers spent a significant amount of time on whole class instruction. Teacher A used a problem solving task to introduce the lesson though the students and teacher worked together through the two introductory examples. None of the lesson plans and artifacts included the use of problem solving tasks as part of the lecture.

According to the survey results, students in these classes answer textbook/worksheet questions and practice mathematics facts, rules, or formulas daily. The data from the observations and artifacts supports these findings. Teachers in all four classes provided time in

class for students to work on homework. Teacher G lectured the entire hour but students were to work on the assignment during the next class period. Teacher E provided worksheets to collaborate this while Teacher C and G included homework assignments from the text. Reinforcing the importance of homework in these classrooms, Teacher C stated in the interview “practice makes perfect in math is true.” While teachers emphasized the properties and rules during the lecture, math facts were not practiced in any of the classrooms at high performing schools.

Three of the four teachers reported having students read from the textbook in class slightly more than once or twice a week while the fourth teacher reported implementing this practice once or twice a year. The teachers did not require students to read out of the text in any of the lessons observed or artifacts that were examined.

Other similarities were found between teachers at high performing schools from the data collected in surveys, interviews, observations, and collection of artifacts. Table 4.25 illustrates findings that were associated with the *Principles*.

**Table 4.29: Data Collected from Teachers at High Performing Schools**

	Teacher A	Teacher C	Teacher E	Teacher G
Equity	Reteach	Reteach/Retest	Extra Help	Extra Help
State Assessment Practice	Throughout year, week before	Throughout year, week before	Throughout year, week before	Throughout year, week before
Multiple Representations	Table, function, verbal, graph	Table, function, mapping, graph	Function, graph, technology, verbal	Function, graph, table, verbal, technology
Determining Students in-progress	Homework, In-class	Homework, Quizzes	Completion grade on homework, quizzes,	Homework, quizzes,
Questioning, prediction, generalization	Yes	Yes	Yes, presented rule first	Yes
Text	Combination of Standards-based and Traditional	More traditional in nature	Combination of Standards-based and Traditional	More traditional in nature

All teachers from high performing schools implemented a similar plan to help those students having difficulty. Teachers A and C both took extra class time to reteach or review a concept students were having difficulty with. Teacher E also spent extra class time as needed but students were encouraged to come in before school during Power Period to get extra help. Teacher G encouraged students to ask questions and get help anytime he was not lecturing.

All teachers from high performing schools integrated at least four different representations of functions into the lesson including a table, function notation, graphs, mappings, verbal descriptions, and technology. All teachers also followed a model of questioning students first, having students predict, and then making a generalization after several examples. Both of these practices are in line with the recommendations put forth in NCTM *Principles and Standards*. These four teachers from high performing schools were also consistent in their implementation of both formal and informal assessments to determine student progress.

Another similarity was found in the manner in which teachers from high performing schools approached the state assessments. All teachers were concerned about students performing well on these assessments but were more likely to incorporate the material throughout the year. Teachers would give students a quick review and practice on the computers two to three days before assessments were given. Students were encouraged to do well and know the material but were not required to dwell on the assessments all year.

### ***Teachers at Low Performing Schools***

Three of the four teachers from low performing schools had between six and fourteen years of experience while the fourth had more than twenty-five years. The same three teachers had not taken any additional courses in mathematics education while the fourth has received a graduate degree with a major or specialty in mathematics education. A variety of textbooks were used in the algebra classes. Only Teacher H taught a subject other than mathematics. All classes had between 11-25 students. Though all teachers were aware of *Principles and Standards*, only one of the four teachers had read them.

Facilitating group work through seating and problem solving was reported to happen once or twice per week by teachers at low performing schools. During the observations, group work was not implemented as a specific strategy for the lesson, but students were allowed and encouraged to work together while completing homework. Teacher H was the only teacher to submit plans for a group project to be completed over a period of time.

Teachers reported encouraging the use of manipulatives, alternative methods, or multiple representations in problem solving (survey questions 14, 15, 18, 20, and 22) approximately once or twice per month. None of the classrooms had traditional manipulatives readily available for the students; though two of the four classrooms had access to TI-81 calculators. The students in the remaining two classrooms had access to scientific calculators. All four teachers used multiple representations while teaching the new material and encouraged students to use the various methods while solving the homework problems. Questions from the worksheets and tests encouraged students to work with the function notation and the graph of each function.

Two of the four teachers at low performing schools required students to collect homework, notes, tests, and quizzes in notebooks to be evaluated by the teacher or parents. Teachers D and F encouraged students to take notes, however none of the four teachers reported

using journals, written reflections, or students' notebooks as a way to determine students' progress in mathematics class.

Many of the artifacts received from these four teachers were formal exams and practice worksheets. Information taken from these assessments helped to triangulate data from questions 29, 30, 38, 39 on the survey. Teacher D was the only one who reported using student notebooks/journals as a method of assessment. The test received from Teacher B encouraged students to show work and demonstrate some level of understanding of the concepts. This test also had one question asking students to discuss the symmetry of a graph. The test from Teacher H was strictly multiple choice; however, the teacher had marked certain problems for which students were required to show work. Teacher F submitted a test which did not appear to have questions that required a great deal of work and no space was available on the test to show work. None of the questions on the aforementioned tests were written to encourage descriptions or explanations. In addition, teachers reported having students work problems at the board more than once or twice a month which was observed in Teacher B's classroom. The use of individual white boards was mentioned during the interview as a way for students to practice the new material.

Teachers reported explaining new mathematics content almost daily to the entire class (question 33); but only use a problem solving task for students to discover the concept before more formal explanation once or twice per month (question 34). In each of the classrooms observed, teachers spent a significant amount of time on whole class instruction. Teacher B used practical context to introduce the lesson; however, this activity would not have allowed the students to discover the concept before more formal presentation. None of the lesson plans and artifacts included the use of problem solving tasks as part of the lecture.

Data from observations and artifacts supports the survey results that students in these classes answer textbook/worksheet questions and practice mathematics facts, rules, or formulas on a daily basis. Teachers in all four classes provided time in class for students to work on homework. None of the teachers lectured for the entire hour and all reported trying to allow at least fifteen minutes for homework per day. Teacher D had students practice squaring and cubing numbers together as a class, as well as emphasized the laws of exponents. No other classroom in a low performing school was observed practicing or memorizing facts, properties, or laws.

Three of the four teachers reported having students read from the textbook in class slightly more than once or twice a week while the fourth teacher reported implementing this practice once or twice a month. Teacher H was the only one observed having students read out of the text. Other similarities were found between teachers at low performing schools from the data collected in surveys, interviews, observations, and collection of artifacts. Table 4.26 illustrates findings were aligned assessment, representations, and some teaching practices.

**Table 4.30: Data Collected from Teachers at Low Performing Schools**

	Teacher B	Teacher D	Teacher F	Teacher H
Equity			Reteach Before school	
State Assessment Practice	Intensive Practice (2006)	Intensive practice (2006)	Throughout the year, week before	Throughout the year, week before
Multiple Representations	Function, graph	Function	Function, graph	Function, graph
Determining Students progress	In class	In class	Homework, test scores	Homework, in class
Questioning, prediction, generalization	Not observed	Yes	Yes	Not observed
Text	More traditional in nature	More traditional in nature	More traditional in nature	More traditional in nature

Only one of the four teachers discussed or was observed implementing a plan to help those students having difficulty with a particular topic. Teacher F mentioned reteaching and was observed helping many students before school. Other teachers mentioned using in class observation as a method to determine student’s progress but did not mention opportunities for students to gain extra help.

Teachers from low performing schools integrated at most two different representations of functions into the lesson including functions and graphs. Two of the four teachers followed a model of questioning students first, having students predict, and then making a generalization after several examples. The other two teachers were not observed following this model.



Teachers from low performing schools approached preparation for the state assessments in a similar manner. All teachers were concerned about students performing well on these assessments. Two of the four teachers were more likely to incorporate the material throughout the year with a short intensive review two to three days before assessments were given. During the time of this study, two of the schools had taken drastic measures to improve test scores by adding a test preparation class or by having students take extra school time to review every day for the three months before the assessments were given.

### *Summary of Triangulation*

Teachers at low performing schools report students collaborating to solve problems more frequently than those teachers at high performing schools. Two of the four teachers at high performing schools did not appear to encourage group work during the observation while all teachers from low performing schools allowed and/or encouraged students to complete homework together. Only one teacher from any of the schools provided a project in the artifacts that promoted students working together on a large project.

More students in high performing schools had access to more recent technology. Algebra II students in high performing schools all had access to TI-83 graphing calculators while those students in low performing schools had access to either a TI-81 graphing calculator or a scientific calculator. All teachers from high performing schools appeared to use multiple representations of functions (graphs, tables, function notation, etc) and assessed students' ability to use of the various representations more frequently than those from low performing schools.

One teacher in each category had students write in a notebook/journal or collect their work in a portfolio. More questions on tests from high performing schools encouraged students to write than did those from low performing schools. Also, more questions from the assessments could have more easily been adapted to include explanation or descriptions than assessment questions from low performing schools implying students had to make connections and use reasoning to successfully answer the questions.

All eight teachers used lecture as the primary method of explaining new content to the students. This was evidenced through survey results, observation, interviews, and the lesson plans which were submitted. None of the eight teachers used a problem solving task before more formal explanation during the observation. Two teachers, one from a high performing school

and one from a low performing school, prepared lessons with initial examples which would be considered more standards-based than the others; however, the lesson was very traditional in nature.

In general, the teachers in high perform were more concerned with the laws and properties of mathematics than those in low performing school. This could be evidenced during the observation as well as on the exams. Teachers from low performing schools included more real-world context or discovery type activities to direct the lesson.

### **Summary**

The purpose of this study was to determine the extent to which mathematics teachers in high and low performing rural high schools in Kansas demonstrated teaching practices in alignment with the vision of the NCTM Standards. Although the results presented in Chapter 4 do not suggest any blatant differences between the teaching practices of those teachers in high and low performing schools, there were subtle differences that must be examined in more detail. In addition, some of the most obvious differences, such as time spent in class and the availability of extra help, are not directly associated with teaching practices associated with *Principles and Standards*. A discussion of the results, conclusions, and recommendations for future research follows in Chapter 5.

## CHAPTER 5 - Conclusions

### Introduction

*Principles and Standards* reflects society's need for mathematical literacy, inclusion of appropriate technology, and presents a set of goals for which mathematics educators should strive to achieve (NCTM, 2000). By asking educators to imagine a classroom where all students have access to high quality mathematics instruction, *Principles and Standards* encourages educators to provide students with opportunities to learn mathematics with understanding. The five Process Standards of Problem Solving, Connections, Communication, Representations and Reasoning guide mathematics educators to present content in a manner congruent to those ideals set forth in the Principles. Specifically, students in standards-based classrooms will have access to technology and manipulatives, aiding in the solving of complex mathematical tasks to enhance learning. Each mathematics teacher will have the pedagogical content knowledge to assist students in making connections between previous and new content. Students will value mathematics, work collaboratively to gain mathematical knowledge, and then communicate their findings to others (NCTM, 2000). Students will engage in complex learning that draws on previous knowledge and integrate knowledge from a wide variety of topics. Students will represent mathematics in a variety of ways while developing, refining, and testing conjectures based on data they have collected. In addition, students will be able to work productively and effectively alone or in groups and communicate their mathematical ideas to others (Florian, 2001; NCTM, 2000). These ambitious goals set forth in *Principles and Standards* and the impact on student learning should be studied.

There are many factors that may contribute to students' success or lack thereof on state assessments but the pressure to succeed on state assessments affects every teacher at almost every level. A small percentage of rural high schools in Kansas achieve Standard of Excellence in mathematics consistently. At the time of the study, Standard of Excellence in mathematics was achieved by at least 15% of students scoring Exemplary and no more than 15% of students score Unsatisfactory. It is expected that 40% of students will score Advanced or above, 70% score Proficient or above, and 85% will score Basic or above on the assessment (KSDE, 2006).

A much larger percentage of rural high schools in Kansas consistently have at least 50% of students scoring at Basic or below on the state mathematics assessment. Despite various efforts to integrate standards-based practices in mathematics classrooms across the country, and despite evidence suggesting standards-based practices improve student learning (NCTM, 2000), some teachers do not embrace the message of *Principles and Standards* or implement standards-based practices in their classrooms. This study investigated the extent to which teachers in high and low performing schools in Kansas demonstrate teaching practices in alignment with the NCTM *Principles and Standards* through examining behaviors of high school mathematics teachers. The following questions provided the specific foci of the study:

1. To what extent do teachers in high performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
2. To what extent do teachers in high performing rural high schools implement teaching practices aligned with the NCTM Algebra Content Standards?
3. To what extent do teachers in low performing rural high schools demonstrate teaching practices aligned with the NCTM Process Standards?
4. To what extent do teachers in low performing rural high schools implement teaching practices aligned with the NCTM Algebra Content Standards?

This two-phase study was a mixed design using both quantitative and qualitative data from four main sources: survey, interview, observation, and collection of artifacts. Phase I of the study included surveying all mathematics teachers in high performing (those schools achieving Standard of Excellence in mathematics during 2003-2005) and low performing (those schools with at least 50% of students scoring at Basic or below on the state mathematics assessment during 2003-2005) rural high schools throughout the state of Kansas. The data collected in Phase I was used to examine differences and similarities in teaching practices of teachers from high and low performing schools. The Kansas State Department of Education (KSDE) website along with data collected in the survey was used to create a smaller set of four matched pairs for interviews, observations, and collection of teacher work samples throughout Phase II. The data collected in Phase II was analyzed to further explore any existing patterns among high performing and low performing schools. Results from teachers in high and low performing schools were compared and contrasted to determine if there were differences between the teaching practices that were demonstrated by each group of teachers.

Phase II of the study allowed the researcher to gain indepth information from the smaller sample of four matched pairs by interviewing, observing, and analyzing teacher work samples all based on a unit covering functions. The researcher interviewed and observed one teacher in each school to determine how the Principles and Process and Content Standards were implemented into the classroom. The five principles presented in *Principles and Standards* include Curriculum, Assessment, Teaching, Technology, Learning, and Equity. Process Standards included Problem Solving, Reasoning and Proof, Communication, Connections, and Representations while Content Standards include understand patterns, relations, and functions, represent and analyze mathematical situations and structures using algebraic symbols, use models to represent and understand quantitative relationships, and analyze change in various contexts. In addition, the researcher examined the interaction between students and the classroom teacher as well as interactions with each other to determine if students were given opportunities to explore and investigate data, make conjectures, and explain and justify their reasoning and conclusions. The third stage of Phase II included collecting teacher work samples taken from the functions unit, including lesson plans, student tasks, assessments, and assignments which were used to gain an indepth look at teacher practices related to the mathematical content. Analysis of the these data revealed observed behaviors of rural high school teachers concerning standards-based practices; indicated possible relationships between teacher behaviors concerning standards-based practices and success on state mathematics assessments; as well as exposed any similarities or differences between high performing and low performing schools.

## **Summary of Results Related to Research Questions**

### ***Question 1***

The purpose of the first question was to determine the extent to which teachers in high performing schools demonstrated teaching practices aligned with the NCTM Process Standards of problem solving, reasoning and proof, communication, connections, and representation. Analysis of the quantitative and qualitative data revealed the majority of teachers from high performing schools implemented some standards-based practices. All of the classrooms observed were considered more traditional than standards-based.

While more than half of teachers from high performing schools required students to solve real-world problems individually and collaboratively, very few, if any, used these types of problems for students to discover the content before more formal explanation. There was little or no evidence of teachers in high performing schools providing opportunities for problem based learning. Additionally, teachers in high performing schools did not require students to work on extended mathematics investigations or projects. Teachers reported implementing problem solving in the classroom but this was not observed. Almost all teachers reported students completing homework from texts or worksheets on a daily basis.

Students in high performing schools were expected to find and use alternative methods when solving a problem and draw connections between previously learned content and new material. The typical classroom consisted of questions, lecture, and time for homework. Teachers in high performing schools provided numerous examples and assessed students' understanding formally through homework and informally throughout the lecture. Each teacher explicitly connected the new material to content that had been previously learned. Assessments from teachers at high performing schools included short answer, multiple choice, and open-ended responses which required the students to make connections between the various representations and uses of functions.

Communication between students was minimal as teachers from high performing schools did not promote group work as much as teachers from low performing schools. Communication between teacher and students was very high as these teachers provided many opportunities for students to discuss mathematics and get help outside of class. Students were not required to keep journals, write reflections, or write a description of a plan, procedure or problem solving process on a regular basis but many students did take notes during the lecture.

Teachers from high performing schools questioned students, had students predict, and helped them make generalizations about the characteristics of functions covered in the lesson. All four teachers followed this pattern with only one of the four giving students the rule first. Questioning students to lead them to the point of generalization is a powerful practice supported by the NCTM *Principles and Standards*.

More than 75% of teachers in high performing schools explained a new topic using multiple representations more than once or twice a month. During observations, teachers used various representations of functions and encouraged students to use these multiple

representations to solve various problems. Teachers at high performing schools implemented more representations during a lecture than their counterparts. All teachers from high performing schools used at least three representations of the functions during the class as well as assessed students' understanding of the various representations.

Although the study was primarily focused on the implementation of the Process Standards put forth in *Principles and Standards*, further examination of the data revealed differences in the integration of the Principles. Teachers in high performing schools appeared to address the Equity, Teaching, Technology, and Assessment Principles more than teachers from low performing schools.

Two of the four high performing schools had implemented practices to give all students additional opportunities to learn mathematics. Students from Teacher E's class were encouraged to ask questions during Power Period before school. Those students earning a "D" or "F" were required to attend, but many other students took advantage of this opportunity to better understand the mathematics. All students in Teacher C and G's school were given the opportunity to ask questions of their teacher as long as the teacher was not lecturing. In addition, Teacher G's school had established a plan to monitor students considered "at-risk." These students were not required to get extra help but were encouraged to take advantage of the opportunities given to them. Teachers recorded the assistance given to these "at-risk" students in order to assess their needs in a more consistent manner.

Teachers from high performing schools appeared to more consistently address components of the Teaching Principle. NCTM states "the teacher is responsible for creating an intellectual environment in the classroom where serious engagement in mathematical thinking is the norm" (NCTM, 2000). Teacher A implemented various strategies including guided discovery and group work to provide opportunities for students to engage with the mathematics. Teacher E and G encouraged all students to take notes. Teacher G also implemented guided discovery while creating a quiet classroom for students to work through and understand the material on their own. In addition, the teaching principle also recommends that teachers know the mathematics students need, understand the different ways the mathematics can be presented, and be able to represent mathematics as a connected whole. Teachers from high performing schools frequently and consistently used at least four different multiple representations of functions including, verbal, function notation, graphs, and tables.

Students from high performing schools had access to more advanced and newer technology than those students in low performing schools. Teachers in high performing schools used the graphing calculator as part of the instructional process to illustrate and solidify the mathematical concepts covered during the lessons. The graphs created by the calculators were not used in isolation but rather supported and reinforced those ideas established throughout the lesson. These practices are in alignment with the Technology Principle.

Finally, teachers from high performing schools addressed the Assessment Principle to a greater extent than those teachers from low performing schools. In high performing schools, assessment was part of the educational process. Two of the four teachers from high performing schools personally graded students' homework including written feedback. Three of the four teachers used quizzes as a method to consistently measure students' understanding of the mathematical concepts. Tests and quizzes from teachers at high performing schools assessed students' understanding of the multiple representations used to teach the concepts. These formal assessments in conjunction with classroom observation and communication were used to determine if the teacher needed to spend time reviewing, re-teaching, or continuing with new material.

### ***Question 2***

The second research question asked to what extent teachers in high performing rural high schools implement teaching practices aligned with the NCTM Algebra Content Standards. No teacher should cover all of the algebraic content standards in one lesson. In the current study, functions were used as the unifying concept to determine the extent to which teachers in high performing schools implement the following: understand patterns, relations, and functions, represent and analyze mathematical situations and structures using algebraic symbols, use models to represent and understand quantitative relationships, and analyze change in various contexts.

From the observed lessons, teachers from high performing schools implement teaching practices aligned with the NCTM Algebra Content Standards. Opportunities were created for students to view different patterns and use abstraction when appropriate. Given numerical patterns students could extend the pattern and explicitly define the relationship. All teachers from high performing schools stressed the importance of using different representations of functions by integrating the use of graphs, tables, equations, and the appropriate technology.



None of the teachers were observed explicitly teaching a lesson covering the various characteristics of functions; however, students had a working vocabulary of these ideas which allowed them to learn the new material. Very few teachers were observed analyzing and interpreting rates of change in the classroom; however, during the interview, the various approaches to slope and rates of change were discussed. In most cases, teachers from high performing schools would begin the lesson with the definition of slope to help students understand the meaning and purposes of slope.

All students in high performing schools appeared to understand the meaning of equivalent forms of linear expressions, equations, and inequalities. Only one high performing school was observed using the various classes of functions; yet all textbooks eventually addressed other classes of functions. Students were expected to work effectively and interchangeably with the various representations of functions on homework and assessments. In each classroom there was a need for symbolic algebra to be used. Students also were encouraged to understand the meanings and reasonableness of the symbolic manipulations and those observed via the technology.

Furthermore, two of the four teachers incorporated real world applications into the lecture. Through discussion with the teacher, students were able to draw reasonable conclusions while modeling a situation using functions. In addition, these students were required to make connections between the various representations, functions, and applications on homework and through formal and informal assessments.

### ***Question 3***

The purpose of the third question was to determine the extent to which teachers in low performing schools demonstrate teaching practices aligned with the NCTM Process Standards of problem solving, reasoning and proof, communication, connections, and representation. Analysis of the quantitative and qualitative data revealed the majority of teachers from low performing schools implemented some standards-based practices. Although not statistically significant, teachers from low performing schools answered nineteen of the twenty-seven survey questions concerning classroom practices in a more standards-based manner than teachers from high performing schools.

According to survey responses, considerably more than half of teachers from low performing schools required students to solve real world problems individually and

collaboratively. There was little or no evidence of teachers in low performing school providing opportunities for problem based learning before or after more formal instruction. Although the difference was not statistically significant, more teachers from low performing schools reported students working on extended mathematics investigations or projects but only one of the observed teachers appeared to implement this into the curriculum. Almost all teachers report students completing homework from texts or worksheets on a daily basis.

Students in low performing schools were expected to find and use alternative methods when solving a problem and draw connections between previously learned content and new material. The typical classroom consisted of questions, lecture, and time for homework. Teachers in low performing schools were more likely to include more real-world examples earlier in the lesson while informally assessing student understanding throughout the lecture. Although the differences were not statistically significant, more than 75% of teachers in low performing schools reportedly explain a new topic using multiple representations on a regular basis. During observations, students from low performing schools were encouraged to use functions and graphs to solve various problems; however, students from high performing schools were more likely to use more representations including functions, graphs, tables, and technology. Assessments from teachers at low performing schools included short answer, multiple choice, and open-ended responses.

Teachers from low performing schools reported allowing students to work in groups more frequently than their counterparts. This practice was also observed in the various classrooms. The use of groups tended to encourage communication between students; however, the increased communication did not necessarily include mathematics. According to survey responses, students were more likely to work on extended mathematics investigations or make formal presentations to the class as well as journal, write reflections, and write a description of a plan, procedure or problem solving process; however, none of these practices were observed in any of the low performing classrooms.

Teachers from low performing schools were more likely to integrate informal assessment into the mathematics classroom as the primary method of determining student's progress. The Assessment Principle encourages the integration of both informal and formal methods of assessment to gain appropriate knowledge of student's progress to make appropriate instructional decisions. Although teachers from low performing schools used formal assessments at the end

of a chapter, they were more likely to use multiple choice questions and less likely to require higher order thinking than those tests given by teachers at high performing schools. In addition, quizzes were not used as frequently as a method to assess student understanding of new material.

The Technology Principle emphasizes that technology is essential in teaching and learning mathematics. Technology changes what is able to be taught, the method it can be taught, and enhances student's learning. All schools had access to computers, although students were not observed using them as part of the mathematics class. Students in low performing schools were more likely to have access to a TI-81 calculator or a scientific calculator while students in high performing schools had access to newer technology.

#### ***Question 4***

The fourth research question asked to what extent teachers in low performing rural high schools implemented teaching practices aligned with the NCTM Algebra Content Standards. Functions were again used as the unifying concept among all teachers to determine the extent to which teachers in low performing schools implement the following: understand patterns, relations, and functions, represent and analyze mathematical situations and structures using algebraic symbols, use models to represent and understand quantitative relationships, and analyze change in various contexts.

From the observed lessons, it appeared that teachers from low performing schools implemented teaching practices aligned with the NCTM Algebra Content Standards. Although students were not observed specifically working with patterns, students were expected to recognize patterns in equations and graphs and make generalizations based on their observations. Students were not observed working with transformations or functions other than linear; however, all topics were covered in the text. Students were given opportunities to work with different representations of functions in a variety of contexts as well as use abstraction when appropriate. Teacher H led students in a discussion to draw reasonable conclusions about a situation being modeled. All students were exposed to symbolic algebra.

## Discussion

### *Discussion of Results Associated with Teacher Practices and the Principles and Standards*

The daily classroom practices of teachers in high and low performing schools were not vastly different from each other. Most adhere to the traditional practices of lecturing for part of each class period followed by students completing textbook exercises or worksheets on a daily basis. All teachers reportedly support and implement some standards-based practices. It is important to note that all teachers were very aware and knowledgeable concerning the state standards; however, based on results from interviews and observations teachers may not be as aware of the Standards on a national level.

Students in low and high performing schools were expected to find and use alternative methods when solving a problem and draw connections between previously learned content and new material. Teachers in high and low performing schools questioned students, had students predict, and helped them make generalizations about the characteristics of functions covered in the lesson. While all teachers from high performing schools followed this pattern, three of the four did not give the generalization first but rather assisted the students in reaching the point of generalization on their own. These same teachers also implemented a larger variety of representations into the classroom than their counterparts from low performing schools. It is reasonable to predict that those students who are given the opportunity to work with multiple representations have a better understanding of the concepts being studied. Those students from low performing schools were only required to work with graphs and function notation while students from high performing schools were given the opportunity to use tables and technology to learn the concepts as well. While teachers from low performing schools reportedly have the same expectations of their students as teachers in high performing schools when using multiple representations and solving problems, it appears that students are not receiving the same set of tools from which to work.

According to *Principles and Standards*, in classrooms that are implementing standards-based practices, students should: solve real world problems independently and collaboratively, have access to technology and manipulatives, approach problems from multiple perspectives while using multiple representations, make, refine, explore, and prove conjectures, communicate with each other and the teacher, and reason to justify conclusions (NCTM, 2000). Using data

from observations, it appears that students from high performing schools are given more opportunities to solve problems independently, work with multiple representations, and explore, make, and refine conjectures. Students from low performing schools are given more opportunities to work collaboratively and communicate with each other during the lesson.

Teachers in a standards-based classroom provide opportunities for problem based learning; encourage communication, the use of technology, and manipulatives; use divergent questioning strategies, and assist students in making connections to mathematics content as well as other disciplines (NCTM, 2000). Neither group of teachers provided opportunities for problem based learning. As previously stated, teachers in high performing schools had access to newer, more advanced technology and implemented it into the classrooms. It is the belief of the researcher that teachers in high performing schools gave students more opportunities to communicate with the teacher while students in low performing schools had more opportunities to communicate with each other. Two of the four teachers from high performing schools encouraged students to come in anytime and ask questions of the teacher. Two of these schools had implemented plans to give “at-risk” students or those failing a class additional time and resources before school. From observations and interviews, only one of the teachers from low performing schools had a similar plan. It would be beneficial to more closely examine each teacher and schools’ philosophy for providing extra assistance.

McCaffrey (2001) found that there is some evidence that the use of instruction consistent with standards-based practices in high school algebra and geometry classes is related to higher student achievement using a standards-based curriculum. There was no such evidence when using a traditional curriculum. While most schools in the current study did not use a completely standards-based curriculum, some schools had met standard of excellence in mathematics for a number of consecutive years. Two of the four high performing schools used the University of Chicago School Mathematics Project books, a combination of standards-based and traditional ideals, although their classroom was structured in the same traditional manner as the others.

While students were working on homework at the end of the lecture, it was interesting to note the differences in teacher interaction with students at this time. Two of the four teachers in each category were very active in helping their students work through the assigned problems. These teachers were circulating around the room, questioning students, and keeping students on task. The remaining two teachers from high performing schools were available for the students

at all times. Teacher C sat at the front of the room, observing students work, and waiting for students to ask questions. Teacher G's students were not observed in a traditional homework environment; however, Teacher G stated repeatedly to the researcher and to the students that as long as he was not lecturing any student from any math class could come and ask questions. The remaining two teachers from low performing schools appeared less available to the students than any of the other six teachers observed. Students in Teacher D's class did ask questions of the teacher while they were doing homework; however, the teacher was busy working and did not appear focused on the student activity.

There is always the possibility that teachers may help students too much, decreasing students' opportunity to work through the content in their own minds. Teacher B said "I might help them too much and not be strict enough on some things. I think I might hinder them." In contrast, other teachers do not help students as much. Too much help or the lack of help may reflect the teacher's beliefs in the students and their ability or inability to do mathematics. While many teachers stated that student's work ethic would determine the level of success, some teachers felt the teacher was responsible for student success. Perhaps the teachers' level of involvement in helping students is critical in determining student success and should be studied in further detail.

The Algebraic Content Standard suggests students understand patterns, relations, functions, represent and analyze mathematical situations and structures using algebraic symbols, use models to represent and understand quantitative relationships, and analyze change in various contexts (NCTM, 2000). Students in high performing schools were given opportunities to observe, extend, and explicitly define the relationships in various patterns. Students were also asked to make generalizations after observing various patterns related to the different functions. All teachers from high performing schools stressed the importance of using different representations of functions by integrating the use of graphs, tables, equations, and the appropriate technology. Students were able to interchangeably work with a variety of different forms and representations of functions during lecture, on homework, and assessments. Furthermore, two of the four teachers were observed having students represent and analyze situations using functions.

Teachers from both categories report using and encouraging students to use multiple representations. Observation revealed teachers in high performing schools used at least three

different representations during observations. All teachers from high performing schools used function notation and graphical representation in addition to at least one from the following: table of values, verbal, and technology. During observations, teachers from low performing schools used only function notation or graphical representation during the lectures.

### ***Discussion of Results of Teacher Practices Associated with the Principles***

All teachers from high and low performing schools in rural Kansas were surveyed to gain demographic information as well as information concerning classroom practices. The focus of this study was on teaching practices of those teachers in high and low performing schools; however, some interesting results associated with the Equity, Assessment, Technology, and Teaching Principles in *Principles and Standards* were discovered.

One component of the Equity Principle is high expectations and worthwhile opportunities for all (NCTM, 2000). Throughout the interviews, the amount of time available for students to receive additional help significantly varied between the high and low performing schools. Teacher E's high performing school implemented a Power Period for students to get extra help. These thirty minutes before school were required for students failing a course; however, any student wanting extra help could meet with teachers during this time. Many students took advantage of this opportunity. A program for "at-risk" students was implemented at Teacher G's high performing school. Those students labeled "at-risk" were encouraged and allowed to meet with teachers before, during, or after school to gain extra help. In addition, Teacher G encouraged all students to come get help anytime he was not lecturing. Teacher A from a high performing school, though not specifically mentioning the availability for extra help, discussed more individual attention as one of the advantages for students at a small school. The availability for extra help was also not specifically mentioned by Teacher C, but various students came to ask questions while the researcher was observing the classroom.

During the interview, teachers were asked how they assess students' progress. The Assessment Principle states that assessment should enhance students' learning and help teachers make instructional decisions (NCTM, 2000). Teachers from high performing schools relied heavily on a more formal approach using homework and quizzes first, followed by in class observation second. Those teacher from low performing schools relied primarily on a less formal approach using teacher observation of students during the class lecture. Two of the four teachers from high performing schools graded all of the homework themselves, keeping them in

close contact with students' progress. Only one of the four teachers from low performing schools reported relying on homework and test scores. Observation supported these statements made by teachers during the interview. Teachers from high performing schools would work through examples on a worksheet or work through an example problem from each section of the homework problems before having students work on their own. Those teachers from low performing schools gave examples in the lecture but did not give the students the opportunity for extra review as their counterparts did.

Teachers in low and high performing schools also approached the state assessments differently. In high performing schools, teachers worked to cover the content throughout the entire year with a quick review a few days before the assessments were given while teachers in low performing schools implemented an intense review for a longer period of time. All four teachers from high performing schools stressed the importance of covering the material throughout the year. These teachers also implemented an intensive review, lasting no more than one week, before the state assessments were given. Two of the four teachers from low performing schools implemented some type of intensive review lasting more than one week before the test. Teacher D's school began a standards math course strictly for test preparation. This new practice, implemented in the 2006-2007 school year, would not have impacted earlier test scores. The students at Teacher B's school used time set aside in the schedule for accelerated reader to study every day for the three months before the assessments were given. This practice has been continued into the 2006-2007 school year. The two remaining teachers from low performing schools followed the same format as those teachers from high performing schools.

The Teaching Principle encourages teachers to understand what students know and need to learn and then challenge and support them to learn it well. The students learn through the experiences and opportunities provided by the teachers (NCTM, 2000). Two of the four teachers in each category required or strongly encouraged students to take notes during the class lecture which kept students actively involved in the learning process. Teachers in high performing schools consistently utilized three or more representations of functions in the lecture giving students a more indepth understanding of the mathematical content.

Based on lesson plans, artifacts, and observation, teachers from low performing schools tend to assign more homework problems than those from high performing schools which may



affect students' attitude toward math. Teacher F assigned over sixty problems to be completed by the next day while Teacher D assigned nearly forty problems to be completed by the next class period; both were from low performing schools. Teacher H, also from a low performing school, assigned a worksheet and additional 15-25 problems from the text. One of the four teachers from high performing schools had students complete a worksheet in class and then assigned 15-20 problems from the text while one appeared to assign only worksheets and the others assigned 15-20 problems from the text.

In the standards-based classrooms envisioned by *Principles and Standards*, every student should have access to technology that will facilitate his or her learning (NCTM, 2000). Teachers and students from both high and low performing schools had access to computers in the mathematics classroom. None of the schools were observed using the computers to learn and/or teach mathematics. Teachers from high performing schools were observed using TI-83 and TI-84 graphing calculators to enhance instruction in Algebra II classrooms. If students had access to graphing calculators in low performing schools, they were TI-81 which is a much older model with fewer capabilities. Only two of the four low performing schools were observed using graphing calculators in the classroom. Students in high performing schools were observed using the technology to recognize patterns, assist in making generalizations, and support the algebraic manipulations.

During any given observation of a classroom, one will not see the teacher implement all of the Process Standards or all of the Content Standards recommended by NCTM. The *Principles*, however, should guide every lesson. Further research would help determine how high and low performing schools addressed the Curriculum and Learning Principles.

## **Conclusions**

Data collected concerning the Principles, Process Standards, and Content Standards gives a glimpse into the differences between high and low performing schools. Further research needs to be completed to gain a more thorough understanding of those characteristics and practices that aid schools in becoming and remaining high performing. Six such topics will be discussed in this section.

Although mathematics teachers cannot incorporate all Content Standards and all Process Standards into one given lesson, the six principles should be a guiding force in all lessons.

Teachers from high performing schools were observed implementing the Equity, Teaching, Assessment, and Technology Principles into their classroom with more consistency than their counterparts. Teachers were available to help all students, used and assessed a variety of multiple representations, incorporated informal and formal assessments, and integrated appropriate technology into the mathematics classroom. Further research needs to be completed to determine how the Curriculum and Learning Principles are addressed in high and low performing schools in Kansas.

Secondly, while cooperative learning is not a specific principle or standard stated in the NCTM *Principles and Standards*, it is a practice recommended by NCTM to meet the goals set forth in *Principles and Standards* (NCTM, 2000). The data from the current study shows teachers from high performing schools do not incorporate group work as a teaching practice or as a tool for students to use when working on homework. Teachers from low performing schools allowed students work in groups on a regular basis to complete homework. It is not the opinion of the researcher that the school is low performing because the students work in groups nor do they work in groups because they are at a low performing school. It is possible that those students who consistently work in groups to complete homework are not given the same opportunities to synthesize the information as those who are required to work through the material on their own. According to Johnson, Johnson, and Holubec (1991), cooperative learning should include positive interdependence, interaction, individual accountability, individual and small group skills, and group processing. Although teachers from low performing schools implemented group work more frequently than teachers from high performing schools, none of the aforementioned cooperative learning strategies were observed. Integrating these elements into “group work” encourages students to work together with a common goal of each student truly understanding the material. In contrast, when students work in groups without guidance, their purpose may be just to complete the assignment without any real learning taking place. In addition, state assessments are not given in groups. Assessment should be part of the learning process instead of an albatross attached at the end. Instructing students in the same manner they will be assessed will increase learning and assessment scores.

Perhaps the difference between those students at high and low performing schools is the amount of time spent on task. Those students working individually were apparently thinking about mathematics while their counterparts were discussing non-mathematical topics. This

research is not suggesting that group work should be eliminated from the mathematics classroom but guidelines, purpose, and specific cooperative learning strategies, such as making each student accountable for the other student's understanding, should be incorporated into group work. More research is needed to examine how these strategies may help to maximize learning. Further in-depth study of group work and cooperative learning in high and low performing schools would be necessary to determine how this practice truly impacts those students.

The third apparent contradiction that was not entirely expected by the researcher was that teachers in high performing schools appeared more focused on rules, definitions, and properties than those teachers in low performing schools. These teachers had very structured lectures using algebraic manipulation, rules, definitions, and numerous examples on the chalkboard. All teachers in all classrooms were concerned with the symbolic manipulation required to solve algebraic problems; however, teachers from low performing schools were more likely to include application and investigation to assist the students in learning and understanding the material. These observations caused the researcher to ask the following questions: Are students from low performing schools better able to apply the mathematics to real world situations but this knowledge is not assessed? Are symbolic manipulation, mathematical rules, and definitions the concepts which are measured on state assessments? Are students from high performing schools scoring higher on state exams but perhaps unable to apply the mathematics they are learning? Further research needs to be conducted to answer these questions.

Next, the researcher was only able to interview and observe one teacher from each school. This is not sufficient to gain a meaningful understanding of the culture of the school and other factors that might influence learning. For example, Teacher H was required to teach five different classes every day most of which were in a different classroom every hour. This is not conducive to an organized, fluid, confident presentation of the material. While this teacher did not demonstrate poor teaching practices, it was a very different experience than observing her matched pair. Teacher G taught seven different classes per day but stayed in the same classroom and was very calm and organized throughout the lecture.

The attitudes of these two teachers were also very different. Teacher G expected the students to learn the material and to learn it well. He was available for any and all students at all times throughout the day. In contrast, it did not appear that Teacher H had the same expectations or willingness to help fix the problem with mathematics education at the school. By observing

and interviewing other mathematics teachers at the schools, meeting with administrators, students, other faculty, and examining the entire mathematics curriculum, the researcher could gain a deeper understanding of the underlying belief systems in place at each school. Many times success or failure is a self-fulfilling prophecy. If we, as educators, do not believe that our students can learn the material successfully, the students will not be given the same opportunities to succeed.

This leads to the final point of interest. The teachers from high performing schools were teaching more classes per day because their schools were using the traditional scheduling while more low performing schools were using block scheduling. At the high school level, students need consistent exposure to mathematics in order to understand it. High school students almost certainly do not work on their mathematics homework during the “off days.” Students from high performing schools were spending more time in mathematics class on a consistent basis. Time on task is critical to students learning the material.

Although the schools were carefully matched to eliminate confounding variables, it is the belief of the researcher that there are more than teacher practices affecting the achievement levels of students at rural schools in Kansas. Other mathematics teachers in the building, the K-8 curriculum and teachers, and how much and what portions of the text were covered before the state assessments are all areas that need to be considered. Three of the four teachers from low performing schools did not appear satisfied or passionate about their work. The rural school environment is a special place that should be preserved; however, more needs to be done to ensure all students in rural schools are given equal opportunities to succeed in the mathematics classroom.

Finally, a student’s success or failure in mathematics should not be based solely on the results of one state assessment. All students cannot and will not learn mathematics in the same manner or to the same level of proficiency. It will be more beneficial to examine best teaching practices that will provide all students with the opportunity to learn and use mathematics in a productive manner. The instruments used to assess students also should be examined in greater detail by comparing applications, manipulations, and select items to teaching practices in the classroom. Although the exams are supposed to align with the standards and assess higher level thinking and applications, perhaps closer examination would reveal a different purpose.

## **Recommendations for Further Research**

Using the results of the current study as a guide, future research may be conducted to gain a deeper understanding of teaching practices, the curriculum, and the school environment that may affect the success of students in mathematics.

### ***General Research***

The current study could be repeated in low and high performing urban schools in Kansas, as well as rural and urban schools in other states. Comparisons could then be made between these schools to determine best classroom practices for all mathematics classrooms. Following the same format as the current study but interviewing and observing all mathematics teachers at the high school level would promote a better understanding of the teaching practices effecting student achievement.

It is also noted that three fourths of the low performing schools examined in Phase II of the current study were from southwestern Kansas, while only one of the high performing schools was from the same region. Although the paired schools did not demonstrate any significant differences in LEP, ethnicity, SES, etc, an indepth study of this particular region of the state could help explain this difference.

In order to determine in more detail the differences between high and low performing rural schools in Kansas, complete case studies could be implemented. Since Riordan and Noyce (2001) found students who learned math from a standards-based curriculum in elementary school performed significantly higher on state mathematics assessments, examining the district's K-12 mathematics curriculum and teaching practices at all levels would help to determine the foundation of mathematical knowledge these students are receiving. Studying the extra curricular activities, time of day courses are offered, and the mathematical content an average student receives before taking the assessment would give deeper understanding to what may attribute to success on a state assessment. In the current study the differences in the amount and type of additional help provided for students and the availability of the teacher seemed to be a significant difference between teachers at high and low performing schools. Deeper study would be required to determine to what extent this effects student success on the state mathematics assessment.

The current study focused more on the Process Standards than the Content Standards. The survey and interview questions were designed to determine how teachers were teaching mathematics in contrast to studying the content that was taught. Studying the specific content covered by the teacher and the specific manner in which it was covered could provide deeper insight into the use of standards-based practices. Examining artifacts from more than one lesson could also provide powerful information concerning the Content Standards.

According to Schoen (2003a), there has been little research determining the effectiveness of strategies such as professional development, cooperation with other teachers, more group and pair work, and a variety of assessments used with a traditional curriculum. Observing the effectiveness of implementing these strategies at low performing schools could provide support for effective teaching practices which may improve student achievement. Further research, examining teachers' pedagogical content knowledge and the effect this has on student achievement could also be implemented. Possible professional development opportunities for pre-service and in-service teachers regarding effective cooperative learning could be beneficial for teachers from both high and low performing schools.

Data collected from the survey suggests there may be differences in time students spend collaborating on mathematics. Although a significant difference was not found in the current study, teachers reported students spent more time collaborating to solve mathematics problems and homework in low performing schools than high performing schools. This data was consistent with data collected in interviews and observation. There was not a statistically significant difference between the number of classes taught per day, but teachers in high performing schools consistently taught more classes than their counterparts. In addition, many low performing schools reported using various types of block scheduling. This causes the number of classes taught per day to be different as well as causing large differences in the time spent in the mathematics classroom. Case studies should be implemented to determine how the number of classes, scheduling, and class time affects student achievement.

### ***Mathematics Achievement Research***

State mathematics assessments have become the driving force in the classroom. By critically evaluating the state assessments to determine exactly which NCTM and State Standards are tested, classroom practices could be assessed in conjunction with the specific state assessment. As most teachers at high performing schools continued to teach in a highly

traditional manner, the state assessments could be evaluated to determine the extent to which they are actually standards-based.

It would be beneficial to study the material covered from the textbook by each teacher before the state assessments are given. Most teachers report relying heavily on the textbook to determine their curriculum, perhaps the order in which content is addressed is a component of success on state assessments. The year and semester students take the assessment within their high school career will also need to be considered in future studies.

It is very difficult to classify teacher beliefs and attitudes; however, it appears that teachers' beliefs towards students' ability to learn may impact student success. Some teachers from low performing schools appeared to have a more negative attitude towards achieving student success than those teachers from high performing schools. A qualitative examination of teachers' beliefs toward the standards as well as their associated behaviors could lead to insight in determining students' level of success.

### ***Rural Schools Research***

In the current study, most teachers did not address the advantages and disadvantages of rural schools. However, rural schools are very different from each other and certainly provide a different learning environment than urban schools. Case studies of the rural schools in the current study could be completed to gain a more detailed depiction of each school environment. These then could be compared and contrasted to help determine why such similar schools can have widely varied results on the same assessment.

## **Summary**

*Principles and Standards* published by NCTM in 2000 is a powerful document designed to promote quality education for all students, present goals for mathematics educators to strive to attain, and promote change in the world of mathematics education. Without quality teachers embracing and implementing the recommendations set forth in *Principles and Standards*, the impact of these *Principles and Standards* on students learning of mathematics will be far less than is acceptable by the mathematics education community.

The current study adds to the small knowledge base of information available which assesses the impact standards-based practices have when implemented with a traditional curriculum. Teachers in high performing rural high schools consistently integrated the use of

multiple representations into their lectures, assessments, and homework. Students were given numerous opportunities to interchangeably work with graphs, tables, function notation, verbal descriptions, and appropriate technology to learn mathematical concepts. The researcher believes these actions support the Teaching and Technology Principle in *Principles and Standards*.

In addition to the few studies on mathematics education, *Principles and Standards*, and rural schools, this study begins to illustrate those practices which support student success in rural schools. Students in high performing schools were given various, frequent opportunities to communicate about mathematics with their teachers. Through reteaching, retesting, and extra help provided by the teacher before, during, and after school, these students were expected to learn mathematics with understanding. These actions support the Equity Principle as well as the overarching goal of *Principles and Standards*.

This study provides a springboard to a myriad of other research opportunities to better understand the impact *Principles and Standards* is having on the mathematics education of today's student. Through cases studies of specific rural schools, a better understanding of the implemented K-12 curriculum and teaching practices throughout the school would provide a deeper understanding into the consistent success of such high performing schools. This in turn would lead to professional development of best teaching and curriculum practices to improve student success in mathematics at all levels.



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## Appendix A - Teacher Survey Letter

Dear Mathematics Teacher:

I am a mathematics instructor at Fort Hays State University. Currently, I am pursuing my PhD in Mathematics Education from Kansas State University. As part of my research I will be studying the implementation of practices aligned with the NCTM *Principles and Standards* in rural high school mathematics in Kansas.

The study consists of three parts. First a survey will be used to gather general information concerning your teaching practices in the mathematics classroom. The survey will take approximately 10 minutes to complete. Each survey has a code number which will be used to identify your data to allow comparisons with the data taken from the interview and observation components of the study. Second, I would like to interview at least ten of you in order to gain a deeper understanding of the data gathered from the survey. Finally, I would like to observe on two separate occasions in the algebra classroom as well as speak with you briefly after each observation.

If you wish to participate in this study, please complete the enclosed survey and return it to me as soon as possible in the postage-paid envelope provided. Your participation in this project is strictly voluntary. After receiving your completed survey, I will contact you next fall to set up times for interviews and observations. You can be assured that if you choose to participate, your identity will be kept confidential at all times (i.e. the researcher will be the only person able to link your responses back to you.) All data will either be reported as grouped data or you will be identified by a code number and not by your name or school name.

Your participation in this study is greatly appreciated. By completing the survey and returning it to me you are giving consent for me to use your information in my research; however your information will always be kept completely confidential. If you would like a copy of the final report or if you have any questions, now or in the future, please feel free to contact me at 785-628-5669, or [lyoung@fhsu.edu](mailto:lyoung@fhsu.edu).

Sincerely,

Lanee Young

## Appendix B - Standards-based practices survey

### SECTION 1: IDENTIFYING DATA

1. Gender:            Female    Male
2. Age
  - a. Under 25                  b. 25-34                  c. 35-44                  d. 45-54                  e. 55+
3. Year in which you completed your initial teacher training
  - a. 1960-1969                  b. 1970-1979                  c. 1980-1989                  d. 1990-1999                  e. 2000 or later
4. How many years have you been teaching mathematics in your current district?
  - a. 1-5 years                  b. 6-14 years                  c. 15-24 years                  d. More than 25 years.
5. How many years of experience teaching mathematics do you have?
  - b. 1-5 years                  b. 6-14 years                  c. 15-24 years                  d. More than 25 years.
6. Extent of your formal college training in teaching of mathematics (mathematics education courses, not mathematics content).
  - a. None
  - b. Only what was offered in my initial teacher training program.
  - c. Additional coursework in mathematics education but not a second degree
  - d. A graduate degree (beyond initial certification) with a major or specialty in mathematics education
7. List the mathematics courses you currently teach and the text/curriculum used in each course.

Course	Text	Author	Publisher	Year

8. Average number of students in your mathematics classes
  - a. 10 or less                  b. 11-15c. 16-20                  d. 21-25                  e. More than 25
9. How many different classes do you teach each day?
10. Do you currently teach any subjects other than mathematics? Yes or No
  - a. If yes, what other subjects do you teach?
11. How many days per week and minutes per day does each math class meet?
  - a. 1day                          2days                          3days                          4days                          5days
  - b. Minutes per day: \_\_\_\_\_
12. Are you aware that the National Council of Teachers of Mathematics has prepared *Principles and Standards*, generally called the NCTM *Principles and Standards* for mathematics instruction?
  - a. Yes, I have read them    b. Yes, but have not read them
  - c. Yes, but I don't know much about them.                  d. No, I am not aware of the standards
  - d. Not sure



SECTION II: CLASSROOM PRACTICES

	Never	Rarely (once or twice a year)	Sometimes (once or twice a month)	Often (once or twice a week)	Almost Daily
<b>About how often do you typically do each of the following in your mathematics instruction in math class?</b>					
2. Arrange seating to facilitate small group work	1	2	3	4	5
3. Encourage students to use manipulatives in solving a problem	1	2	3	4	5
4. Ask students to look for alternative methods for solving a problem	1	2	3	4	5
5. Require students to explain their reasoning when giving an answer	1	2	3	4	5
6. Allow students to work at their own pace.	1	2	3	4	5
7. Explain a new topic using multiple representations	1	2	3	4	5
<b>About how often do students in this class engage in each of the following types of activities as part of their mathematics instruction?</b>					
8. Work on solving a real world problem	1	2	3	4	5
9. Record, represent, and/or analyze data	1	2	3	4	5
10. Collaborate with other students in solving a problem	1	2	3	4	5
11. Use multiple representations of information in solving a problem	1	2	3	4	5
12. Write a description of a plan, procedure, or problem-solving process	1	2	3	4	5
13. Work on extended mathematics investigations or projects (a week or more in duration)	1	2	3	4	5
14. Draw connections between previously learned content and new material	1	2	3	4	5
15. Make formal presentations about their projects to the rest of the class	1	2	3	4	5
<b>How often do students complete the following kinds of written work in mathematics class?</b>					
16. Students write reflections about something they learned.	1	2	3	4	5
17. Students collect their best mathematics work in a portfolio.	1	2	3	4	5
<b>How often do you assess student progress in mathematics in each of the following ways?</b>					
18. Review student notebooks/journals.	1	2	3	4	5
19. Give tests requiring open-ended responses (descriptions, explanations, etc)	1	2	3	4	5
20. Have students complete performance tasks individually	1	2	3	4	5
21. Have students complete performance tasks in groups.	1	2	3	4	5
<b>About how often do you typically do each of the following in your mathematics instruction in this class?</b>					
22. Explain new mathematics content to the whole class.	1	2	3	4	5
23. Use a problem solving task for students to discover the mathematical concept before more formal explanation	1	2	3	4	5
<b>About how often do students in this class engage in each of the following types of activities as part of their mathematics instruction?</b>					
24. Answer textbook/worksheet questions.	1	2	3	4	5
25. Read from a mathematics textbook in class.	1	2	3	4	5
37. Practice mathematics facts, rules, or formulas.	1	2	3	4	5
<b>How often do you assess student progress in mathematics in the following ways?</b>					
38. Give short answer tests (multiple choice, true/false, fill in the blank)	1	2	3	4	5
39. Work problems at the board	1	2	3	4	5

Please attach any additional comments you have regarding the implementation of the NCTM Standards in your school.

Follow up

I am willing to be interviewed for this study YES NO  
 I am willing to have observers come into my classroom for this study YES NO

Name \_\_\_\_\_ Phone number \_\_\_\_\_

## Appendix C - Interview Protocol

Name of teacher: \_\_\_\_\_ Interviewer: Lanee Young

School Name: \_\_\_\_\_

Date of Interview: \_\_\_\_\_

Beginning Time of Interview: \_\_\_\_\_ Ending Time of Interview: \_\_\_\_\_

Thank you for being a part of this study and allowing me to come interview you and observe your classrooms. As you recall the purpose of the study is to explain what is happening in rural mathematics classes across western Kansas.

### INTERVIEW

1. How do you decide what mathematics to teach? How do curriculum decisions get made in your school?
2. How would you describe a typical day in your algebra class?
3. If you were to teach a lesson on slope and/or linear equations, describe your approach?
4. How do you decide generally if your students are progressing in math? What changes do you make when you feel that they are not progressing or understanding the material?
5. How do you prepare your students for the state assessments?
6. What attributes to the success of your students in mathematics?
7. What hinders the success of your students in mathematics?

## Appendix D - Pre/Post Interview Protocol

Name of teacher: \_\_\_\_\_

Interviewer: Lanee Young

School Name: \_\_\_\_\_

Date of Interview: \_\_\_\_\_

Beginning Time of Interview: \_\_\_\_\_ Ending Time of Interview: \_\_\_\_\_

Pre-observation questions – to be answered via email before observation.

1. What is the topic of the lesson?
  2. What do you hope the students will learn from the lesson?
  3. How does this lesson fit into what you have been doing previously in class?
  4. What factors influenced how you planned this lesson
- Post observation questions – to be answered in interview format after observation

5. Overall how did you feel about the lesson?
6. Were there any ways in which the lesson was different from what you planned?
7. Would you say that today was a typical day? Why or why not?
8. Do you have additional comments about this lesson?

## Appendix E - Observation Protocol

### I. BACKGROUND INFORMATION

Name of teacher \_\_\_\_\_ Date of Observation? \_\_\_\_\_

Location of class \_\_\_\_\_  
(district, school, room)

Years of Teaching \_\_\_\_\_ Teaching Certification \_\_\_\_\_  
(K-8 or 7-12)

Subject observed \_\_\_\_\_ Grade level \_\_\_\_\_

Observer \_\_\_\_\_ Lanee Young \_\_\_\_\_

Start time \_\_\_\_\_ End time \_\_\_\_\_

**Pre-Observation:** to be completed by the teacher prior to the observation

1. What is the topic of the lesson?
2. What are your goals for the lesson?
3. How will you accomplish these goals?
4. What do you anticipate will be challenging for students? How will you address this?
5. How does this lesson fit into what you have been doing previously in class?

## **II. CONTEXTUAL BACKGROUND AND ACTIVITIES**

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, availability of technology, availability of manipulatives, chalkboard placement, bulletin boards, etc), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate. Describe any teacher and student interaction.

Record here events which may help in documenting the ratings.

### III. LESSON

#### STUDENT AND CONTENT INTERACTIONS

In the space provided give a brief description of the interactions between the teacher and content. Use the following as a guideline.

- A. **Understanding:** What evidence is there that students understand key concepts (conversations, presentations, student work)? What misconceptions are arising and how are those corrected?
- B. **Learning Community:** How do students justify their answers, demonstrate that their strategies work, see connections? How do students use a variety of representations and solution strategies (models, drawing, manipulatives, graphing, tables, technology, writing, etc) to demonstrate their understanding of the mathematical concepts?
- C. **Reflection:** Are students reflective about their learning? Does the mathematics make sense to the students? Are students aware of inconsistencies in their thought processes?

#### TEACHER AND CONTENT INTERACTIONS

In the space provided give a brief description of the interactions between the teacher and content. Use the following as a guideline.

- D. **Content:** What are the key mathematical ideas of the lesson? Describe the procedural or conceptual thinking processes in which the students are engaged concerning the key mathematical ideas. How are connections made to prior work in mathematics, other disciplines and real world situations?
- E. **Opportunities to learn:** What types of opportunities has the teacher created for the students to engage in the material: non-routine vs routine tasks, rote memorization, drill and practice, linking previous knowledge to the new topic, scaffolding, working on problems, exploring situations and gathering data, listening to explanations, reading texts, or investigating, conjecturing and justifying their conclusions?
- F. **Efficiency:** How effectively does the teacher know the mathematics and relate it to other fields? How confident is the teacher in his/her ability to teach the knowledge to the students?
- G. **Pedagogical Content Knowledge:** How did the lesson integrate students' prior knowledge and preconceptions? Describe the ways in which the teacher presents the key mathematical ideas (lecture, boardwork, through tasks, inquiry methods etc)

## STUDENT AND TEACHER INTERACTIONS

- H. Expectations: What types of questioning strategies were visible in the classroom discourse? Describe how the students are actively engaged in the mathematical concepts? How is abstraction encouraged?
- I. Learning Community: Describe how the teacher organized the students during the lesson. How long did students meet as a whole class, pairs, small groups, individually etc? What activities were students engaged in while in the different groups? How do students interact with each other? How do the students and teacher interact with each other?
- J. Communication: Describe how students communicate their ideas verbally and in writing? Were all students active and respected members of the learning community? Where does the authority of the mathematics reside in the classroom?

Continue recording salient events here.

Post observation questions – to be answered in interview format after observation

6. Overall how did you feel about the lesson?
  
  
  
  
  
  
  
  
  
  
7. Were there any ways in which the lesson was different from what you planned?
  
  
  
  
  
  
  
  
  
  
8. Would you say that today was a typical day? Why or why not?
  
  
  
  
  
  
  
  
  
  
9. Do you have additional comments about this lesson?
  
  
  
  
  
  
  
  
  
  
10. Lesson specific questions can be added here.



## Appendix F - Artifact Collection List

Name of teacher: \_\_\_\_\_

School Name: \_\_\_\_\_

Date of Collection: \_\_\_\_\_

Listed below are possible items to be collected from teachers:

- Assessments
  - Formal exams
  - Formal quizzes
  - Informal assessments
- Homework assignments
- In class activities including but not limited to:
  - Worksheets
  - Inquiry based tasks
  - Technology/Manipulative based activities
  - Cooperative learning tasks
  - Writing assignments
- Lesson Plans
- List of technology used in unit on functions
- List of manipulatives used in unit on functions