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Student Voices on High School Mathematics Teaching And Learning: College Student Voices on Teacher Behaviors and Actions Impacting High School Mathematics Achievement

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STUDENT VOICES ON HIGH SCHOOL MATHEMATICS TEACHING AND LEARNING:
COLLEGE STUDENT VOICES ON TEACHER BEHAVIORS AND ACTIONS IMPACTING HIGH SCHOOL MATHEMATICS ACHIEVEMENT

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Student Voices on High School Math

DEDICATION

This dissertation is dedicated to my husband and my children,

Bret A Crane

Aliana L. Crane

Blake L. Crane

for their support and encouragement

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Student Voices on High School Math

ABSTRACT

According to the national Assessment of Educational Progress the national trend in mathematics achievement has not significantly changed from 1973 through 2012 for 17 year olds (National Center for Educational statistics, 2014). Student beliefs about mathematics learning are an important factor in determining the student's math achievement (Woodward, 2004). This qualitative dissertation explores college student perceptions of effective mathematics teaching and learning at the secondary level. Interview participants who are early in their college program were recruited from math classes at a southeastern university. Study participants reinforced the literature that knowing both the how and the why of mathematics is important to them. The desire for ongoing support of their math instruction learning was also identified as necessary by participants as well. Importantly, impediments to learning mathematics at the secondary level were reported by those interviewees in this study. The participant descriptions of effective math instruction support the current literature regarding effective math instruction; however, continued high school mathematics achievement in the United States fails to improve.

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CHAPTER I

INTRODUCTION

This is a qualitative study that explores student views of high school mathematics education and how the student's education has been influenced by teacher behaviors and actions. Data on mathematics achievement from the National Assessment of Educational Progress illustrates that the national trend in mathematics achievement did not significantly changed from 1973 through 2012 for 17 year olds, who are typically high school students (National Center for Educational Statistics [NCES], 2014). Student beliefs about mathematics and mathematics learning are an important factor in determining the student's math achievement (Woodward, 2004). Therefore, interviews with college students were conducted for this study and focused on teacher behaviors and teacher actions to highlight what participants identified as working to improve student mathematical understanding in high school mathematics classrooms. Study participants who were interviewed are those who have matriculated to a four year southern university located in the Commonwealth of Kentucky. This inquiry creates an opportunity to discover views of students who have had some degree of academic success in high school, (specifically high school mathematics), meeting the entrance requirements for admission to the university. By reporting their high school math instruction experiences—instruction that helped them to succeed—these study participants' descriptions can help mathematics educators improve math instruction for students at every level of K-12 education.

Historical Context of Mathematics Achievement

Historically, math instruction in the classroom has changed little throughout the years (Hayes, 1992; Woodward, 2004). Additionally, mathematics achievement as reported in the Trends in International Mathematics and Science Study (TIMSS) reports that student mathematic achievement in the United States has also not significantly changed or improved over time (Bybee & Kennedy, 2005; O'Neil, Abedi, Miyoshi, & Mastergeorge, 2005; Valverde, & Schmidt, 1997). Further, the National Center for Educational Statistics reports the national trend in mathematics achievement has not significantly changed since 1973 for 17 year olds (2014). Improving mathematics achievement of secondary school students has been identified as needed since 1923 (Reyes, & Reyes, 2011). Twenty-five percent of students who graduated high school in 1982 did not take an algebra I course, by 2004 only 5.2% graduated without taking algebra I (Rasmussen et al., 2011, p. 205).

Many states have elected to raise the number of years mathematics is required for high school graduation to improve mathematics achievement (Rasmussen et al., 2011). The adoption of the Common Core Standards in mathematics throughout most of the United States creates the expectation of high school graduates having successfully completed algebra I, geometry and algebra II (Common Core State Standards, 2014). Secondary students are required to complete higher level mathematics curriculum as well as complete an increased number of courses to earn a high school diploma—yet without a corresponding increase in national mathematics achievement scores (NAEP, 2014; Rasmussen et al., 2011). The number of high school mathematics courses has increased through the adoption and implementation of the Common Core Standards without a significant increase in mathematics achievement scores as reported above. Thus, costly math remediation courses continue to increase at the post-secondary level, adding additional time before students can earn a degree (Rasmussen et al., 2011).

The Development of this Study

In the early 1980's, while teaching math at a high desert high school located in Southern California, I became interested in the behaviors teachers exhibit to engage students in learning the assigned mathematics curriculum. In reflecting upon practice to improve student understanding of mathematics, I informally questioned other math teachers regarding how they assisted students in developing mathematical understanding. A pattern emerged over time through discussions with these teachers. Those teachers who self-reported high levels of student achievement additionally expressed concern about increasing student understanding. Other teachers who expressed a belief that the teacher taught and the students learned tended to self-report lower levels of student success from those informally questioned by me. One can only wonder if the teachers who communicated concern about increasing student achievement coupled with accompanying classroom behaviors demonstrating concern may have contributed to student beliefs about their ability to do mathematics-- which has been identified as a contributing factor in mathematics achievement as Smith (2002) describes.

Mathematics has historically been used as a culling ground to divide students into those who will have the opportunity to attend college and those who will not attend college (Aughinbaugh, 2012; Buckley, 2010). The culling of students into separate mathematics tracks has been supported by the high school graduation requirements into the early 1980’s (Aughinbaugh, 2012; Reys, & Reys, 2011). Basic arithmetic and remedial math classes were used to meet mathematics requirements for high school graduation, while colleges were requiring Algebra I, Geometry and Algebra II sequence of mathematics classes for admission. Students who could not learn with traditional lecture model where “teachers teach and students learn” were relegated to the basic or remedial classes, therefore not provided with the opportunity and support needed to meet college entrance requirements in mathematics.

While serving as a high school mathematics department head in the 1980’s, national standards were enacted by the National Council of Mathematics Teachers (NCTM) which suggested that high school students no longer receive math credit for remedial mathematics to meet high school graduation requirements (Reys, & Reys, 2011; “National Council of Teachers of Mathematics”, 2012). The emphasis of the revised standards was to provide all students with the opportunity to take college preparatory math, beginning with Algebra I in either middle school or their freshman year of high school. Some of my mathematics colleagues during this time expressed the belief that instruction beginning with Algebra I for all students could not be accomplished-- that is, if students did not know the basic arithmetic, how could they learn algebra? Math course offerings at my Southern California high school were modified in an attempt to address the suggested NCTM standards as well as the concerns of the math teachers in providing Algebra I courses to all students. As a result, the remedial math classes were dropped, algebra was covered over the course of two years, and students who were weaker in math, enrolled in a math support class as an elective class. The emphasis of the support classes was intended as providing additional time during the school day to improve student understanding of mathematics. The support classes were designed for teachers to provide remediation of arithmetic skills, as well as additional instruction and practice of the topics to be covered in their two-year algebra classes.

Present day math standards, as shown in the Common Core Standards, places Algebra I as an eighth grade class (“National Council of Teachers of Mathematics”, 2012), with all students required to take college preparatory math classes while in high school. Students achieving at lower levels in math are also provided with supplementary services to increase achievement in mathematics, this supplementary service is now called response to intervention (RtI) (Lembke, Hampton, & Beyers, 2012; “Mathematics—Kentucky”, 2012). The emphasis on requiring students to take and pass college preparatory mathematics has increased over time (McKinney, Chappell, Berry, & Hickman, 2009; "National Council of Teachers of Mathematics", 2012). Currently high school students in states who have adopted the National Core Standards in math are required to take Algebra I, Geometry, and Algebra II (Aughinbaugh, 2012; "Common Core State Standards", 2012).

As part of a class project during my doctoral work, I spoke with a focus group of four students from an alternative education setting. These students who volunteered to participate in the focus group provided detailed descriptions of their previous experiences in secondary mathematics classrooms. The students also shared how *their* behavior contributed to their own poor performance in previous math classes, along with identifying teacher behaviors which both assisted and interfered with the students' ability to learn. One student spoke of being direct involvement in activities, including finding the measurement of a light pole using trigonometric functions, as having contributed to learning mathematics. A second student recalled a high school administrator informing him and others from his middle school, that nothing was expected of them academically. The success of the focus group reinforced my belief that student voices are critical and necessary for insights and discussion for improving high school mathematics teaching and learning before educators can begin to increase academic achievement in mathematics for all students.

Purpose

The purpose of this study was to explore teacher behaviors that support learning mathematics while at the high school level, from a student perspective. The learning support students have been provided or not provided while enrolled in high school mathematics was examined since we know that support can influence students to either see themselves as mathematically talented or mathematically challenged (Smith, 2002). The results of this study can be critical when developing new curriculum or working with teachers, principals and schools to improve the quality of mathematics instruction. Currently, there are no other similar published studies using student voice to identify of high school teacher behaviors and actions that help students better learn mathematics.

Currently Kentucky requires that all high school students must take four years of mathematics classes, including passing Algebra I, Geometry, and Algebra II. ("Minimum high school graduation", 2012). The fourth year of mathematics can be a higher level course, a repeat of a mathematics course previously failed, or a transitional course designed to prevent students from taking remedial mathematics at the post-secondary level.

Credentialed mathematics teachers across the United States demonstrate subject matter knowledge through completing required education programs ("Standard routes to certification", 2012), as well as having to pass the subject matter exams. Kentucky also provides support to first year credentialed teachers through the Kentucky Teacher

Internship Program (KTIP) process, requiring first year teachers to work with a supervising teacher from a college or university, an administrator from the high school and a mentor teacher from the school or district to provide support and direction for the new teacher. Therefore, with programs and mentoring programs in place, one would wonder why students continue to fail to achieve in high school mathematics (“National Center for Educational Statistics”, 2012).

Teaching practices and the process used for instruction are more important than the curriculum used to increase student achievement in mathematics (Aslam, & Kingdon, 2011). Support for teachers and administrators on current mathematical trends, including how to engage students in the learning process, can assist in improving student achievement in mathematics (Checkley, 2006). The support provided to mathematics teachers, along with the teacher’s underlying belief in the capability of students to understand and do mathematics, can have a strong impact on the students’ mathematics achievement (Deemer, 2004).

A qualitative approach (Casey, 1995; Saldana, 2011) is used in this study to allow students the opportunity to describe those practices from their math teacher that they believe have most impacted their ability to learn mathematics while in high school. These descriptions of effective math instruction can potentially increase the mathematics achievement of high school students across the nation. The data collection for this study primarily focused on interviewing current college students about their experiences with high school mathematics along with the effect of instruction on mathematics learning.

Context of the Study

The 2010 adoption of the core curriculum standards in mathematics by the Kentucky Department of Education provides a framework for the curriculum and instructional practices in Kentucky to be implemented (“Mathematics—Kentucky”, 2012). The underlying assumption during the implementation of the core curriculum standards is that the curriculum is being consistently adopted within all high schools in the commonwealth. The administrators of the schools and the districts have the obligation to ensure that curriculum and the standards for instructional practices are followed in all mathematics classrooms under the administrator’s purview. The curriculum is mandated to be rigorous and common to all schools in the commonwealth during the ongoing adoption process. The curriculum should be aligned both vertically and horizontally from Kindergarten through twelfth grade. In the era of high stakes testing, the failure of schools to adopt the prescribed curriculum and instructional strategies could create conditions for the school or district to be censored by the Kentucky Department of Education or the community. The reported scores of high school students’ mathematical achievement continue to be below the level of proficiency required by schools, districts, and the commonwealth (“Assessment and accountability—Kentucky”, 2012). As the Kentucky Common Core Curriculum is implemented, with the required end of course examinations, students who struggle in mathematics may not be prepared to pass the test-- causing students to fail the courses (“Minimum high school graduation", 2012). Thus, mathematics achievement is focused on passing the state required tests, not necessarily on higher mathematics achievement (Boaler, 2003). This study can help to increase mathematics scores by identifying instructional strategies and behaviors assisting in improved mathematical comprehension as well as improving high school math achievement.

Instructional Practices

Instructional practices are identified within the Kentucky Common Core Standards as needing to be research based, provide connections to the real world and promote mathematical reasoning, communication and problem-solving ("Mathematics—Kentucky", 2012). The ongoing shift between problem-solving approaches and mastery of formulaic processes within the mathematical community has been studied and restudied (Lewis, 2005; Mervis, 2006; Schoenfeld, 2004). Teaching methods continued to be introduced, used and replaced with other methods. Regardless of the failure to increase student performance as reported in TIMSS (Bybee & Kennedy, 2005), many math classrooms are taught in a traditional manner (Reys & Reys, 2011). The traditional approach to teaching mathematics is instructor led, followed by group or individual student practice, followed by a homework assignment of similar problems to the newly practiced problems. There is an emphasis through the adopted core curriculum standards on using a variety of instructional methodologies including manipulatives (tools used in math classes which allow students to practice math with a tactile approach) and providing time for discussions about mathematics. Teachers are also required to provide instruction to the whole class, small groups and individual students as needed by the class dynamics, as well as involving students in the curriculum ("Common Core State Standards", 2014; "Mathematics—Kentucky", 2012).

Throughout the twentieth and into the twenty-first centuries, mathematics education has shifted between a focus on teaching problem-solving through a formulaic approach or a conceptual approach (Schoenfeld, 2004). A pendulum has, in effect, been swinging back and forth between skills and process with students and educators caught hanging on for a teaching approach ride. Beginning with a movement to teach mathematics as a series of skills and facts which can be memorized and used formalistically to solve problems, teaching approaches then shifted to the opposite end of the spectrum to provide open-ended problem-solving approaches (Schoenfeld, 2004). Both ends of the spectrum have been used to promote teaching and learning mathematics in schools. Mathematics taught as a series of skills to be learned or as open problem-solving has worked for some students; however, mathematics achievement has not drastically improved under either approach.

Conceptual understanding of high school mathematics was characterized by the use of creative problem solving during the 1980's and again in the 2000's ("National Council of Teachers of Mathematics", 2012). This approach was to have the teacher present students with a problem on which students worked individually or in groups to find a solution for the problem. Teachers requested that students articulate the problem-solving approach used to find an answer. The emphasis was on how the students thought about the process, rather than arriving at the correct answer. The teacher's role was to serve as a guide to the process and assist students in clarifying and articulating the thought process.

The formulaic understanding of math is at the other end of the continuum. Using the formulaic approach, teachers provided students with formulas and processes on how to solve problems ("National Council of Teachers of Mathematics", 2012). Teachers checked students' work to determine if correct formulas and processes were used to arrive at the correct solution. Understanding why a particular formula was used was not emphasized. Students were taught that with specific type of problems, a specific approach should be used to solve the problem. The teachers' role was to present the material and have students copy the process to arrive at the correct answer. Both sides of the continuum lead to student learning, providing either the *how* or the *why* in mathematics. From the twentieth century to the present, mathematics classrooms often looked similar, regardless of the approach used to teach (Reys & Reys, 2011).

Student Achievement

International surveys such as Trends in International Mathematics and Science Study report no measurable change in students in the United States performing at or above the advanced international benchmarks for fourth or eighth grade students from 1995 through 2011 (The next administration of TIMSS will be in 2015) ("National Center for Educational Statistics", 2012). Kentucky does not participate in the TIMSS; however mathematics achievement scores for Kentucky students follow national trends (American College Testing, 2013).

The National Council of Mathematics Teachers revised its stance on the desired emphasis in mathematics education, with the most recent revision occurring in 2000 and reflected in the Common Core Content Standards. Kentucky adopted the Common Core Content Standards, including those for math in 2010. The structure of high school mathematics classes has remained consistent with Algebra I (currently considered an eighth grade class), Geometry, Algebra II, Pre-Calculus, and Calculus as the normal sequence of courses. The emphasis within the classes has shifted in accordance with the continuum previously described. Kentucky is among many states currently requiring students to complete Algebra I, Geometry and Algebra II prior to high school graduation ("Minimum high school graduation", 2012). Kentucky currently requires all high school students to be enrolled in math for four years, but not to pass four years of math.

High school students in Kentucky are organized into four categories of math achievement based on state required mathematics standardized test scores (Mathematics—KDE, 2012). These four categories are identified as novice, apprentice, proficient and distinguished. Novice is below grade level; apprentice is approaching grade level; proficient is at grade level; and distinguished is above grade level. The identified levels can be used to divide students into two categories. The first category includes novice and apprentice levels, identifying the student as achieving below grade level in math. The second category includes proficient and distinguished, identifying the student as achieving at or above grade level in math. Given all students in the commonwealth have at least three years of common curriculum, Algebra I, Geometry, and Algebra II, the question as to why students score at differing achievement levels becomes obvious.

Research in mathematics achievement and mathematics teaching has focused on instructional practices and curriculum implementation. The pendulum swinging from formulaic to conceptual understanding has had vocal proponents on both sides as well as mathematics educators wanting to find a middle ground to improve mathematics achievement (Schoenfeld, 2004). The student voice describing best practices in mathematics instruction is a critical component missing within the literature. Though interviews with college students about their high school math instruction experiences, individuals may help to determine which teacher beliefs and behaviors influence students to perceive themselves as mathematically inclined.

Conclusions

Teacher behaviors in the classroom can impact the students' ability to do math (Alper, Fendel, & Fraser, 1997; Smith, 2002). Some teachers are able to motivate and inspire the majority of their students to succeed in mathematics, while other teachers fail. Alper et al. (1997) and Smith (2002) identified 4 conditions needed for students to learn math:

1. Curriculum needs to be understandable and interesting.
2. Personal validation of progress without anxiety.
3. Active engagement and student belief math can be done.
4. Time and reason for students to learn provided.

These conditions can be supported in the mathematics classroom through teacher behaviors, regardless of the curriculum implemented. Students who are not receiving the necessary support in the above four key conditions for learning math may not be demonstrating the achievement needed to pass math classes and progress to the post-secondary level without having to take remedial level mathematics classes.

Since we know that teachers are important to student achievement and learning in the classroom ("Mathematics—Kentucky", 2012), school and district administrators are responsible for ensuring the Kentucky Core Curriculum is used appropriately in the classroom; although the administrators are not expected to monitor classroom activities and curriculum implementation every minute of every class period. School and district administrators should work to develop "positive and productive relationships (Reitzug, 2011)" between students and teachers, among others. The administrative support provided to teachers assists teachers with ("Mathematics—Kentucky", 2012):

- Creating an environment in the classroom conducive to student learning.

- Designing and implementing lessons to increase student learning opportunities.

The behaviors of teachers and what the teachers say or do not say create perceptions with students about the level students are expected to achieve mathematically (Smith, 2002). The perception of students becomes an important factor in the achievement level.

The motivation of student math acquisition is effected by past and present teacher behaviors. One year of negative experiences in mathematics can have an impact on decreasing the student's belief that math acquisition is achievable and that everyone is capable of learning math (Smith, 2002). Student experience can illuminate the effect past teacher behaviors and actions have had on the student's achievement in mathematics. Listening to student voices describe what is occurring in the classroom can assist in creating instructional practices, curricular focuses, and classroom environments supporting student achievement in mathematics.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Before exploring the perceptions of the students interviewed for this study about their high school mathematics experiences, this literature review chapter will first focus on the evolution of mathematics education and our current knowledge within the mathematics instruction field. Specifically, this chapter will include:

- A Brief History of Mathematics
- Academic Achievement
- Instructional Practices

The focus throughout this review is to highlight the significance of teacher instructional behaviors, as well as other teacher characteristics that can enhance learning mathematics. Before educators can improve student achievement, it is important to also examine the persistent shifting of standards in mathematics. Conceptual approaches to mathematics involve a focus on understanding the abstract concepts of mathematics (Schoenfeld, 2004). Formalistic approaches emphasize the use of formulas and sets of rules to complete mathematics. The evolutionary shifts occurring between conceptual and formalistic emphasis in mathematics education are driven by the desire to increase mathematical achievement of students. Student voice regarding mathematics instruction has not been well documented within the literature (DeFur & Korinek, 2009). The use of student voice to improve mathematics education can provide insight into what is currently working within schools to improve education. Creating a student perspective lens about pedagogy can create opportunities understand their achievement, or lack of achievement, in mathematics by providing insights of current teacher behaviors and instructional strategies identified by students as having a positive impact on mathematical achievement levels. In understanding the consistent subpar mathematics achievement in schools (National Center for Education Statistics [NCES], 2014), it is critical to first provide a review of the literature concerning mathematics instruction.

A Brief History of Mathematics

Mathematics education, at the secondary level, is counterpoised between formulistic and conceptual approaches to the curriculum (Schoenfeld, 2004). Evidence through literature can be found to support either approach to mathematics education. Emphasis on finding a middle ground for curriculum development and mathematics education has been proposed as a possibility to increase mathematics achievement for students.

The National Council of Teachers of Mathematics (NCTM) proposed new standards for mathematics, moving away from a formulaic approach to a conceptual approach during 1980's (Hayes, 1992). Attracting students to advanced mathematics classes was the rationale for the shift in emphasis. Standardized tests were used to determine appropriate math classes student enrollment. Teachers used conceptual presentations focused on creating meaning for students who were taught to focus on the process rather than the product obtained. The focus was on solving complex problems according to Alper, Fendel and Fraser (1997). Their study identified four descriptors of successful mathematics curriculum:

- It is vital that the curriculum makes students feel comfortable with the material.
- Personal validation of learning should be provided to students.
- Active involvement in learning should be provided for all students.
- Reasons for solving problems must be provided.

This conceptual shift in the emphasis of teaching was based on a 1989 report, *Everybody Counts,* published by the National Research Council (NRC) on the future of mathematics education. This report highlighted the imperatives of mathematics curriculum to provide all students with a common core of mathematics knowledge-- with additional mathematics provided to those students who planned to attend college. The use of calculators and computers to solve mathematical problems was supported and emphasized as indispensible in all mathematics classes. A student requirement to enroll in mathematics for all four years while in high school was also proposed as a necessity to improve mathematics achievement of students. The emphasis was that students learn to understand mathematics, rather than applying a given set of formulas to solve problems.

The *Everybody Counts* report (NRC, 1989) led to discounting of formulaic teaching of mathematics and subsequently replaced with teachers providing opportunities for students to construct meaning and understanding from interacting with the mathematics. The student interaction with mathematics was done through the use of groups, projects, presentations and other activities providing students opportunities to construct their own knowledge of mathematics. The interaction was identified as providing the experience in math needed by students to increase their individual abilities to apply learned mathematics to new and different problem solving situations. Teachers were to engage students in mathematics' discussions to assist in creating meaning for the student. Teachers were to serve as the guide during these discussions. Interestingly, the *Everybody Counts* report also identified requirements to provide further support for teachers of mathematics to improve the ways in which mathematics is taught, specifically to reduce the over reliance on textbooks and worksheets. Similar concerns resurfaced in 2001 with the entrance of the No Child Left Behind (NCLB) Act, which reported the lack of mathematics achievement. During his campaign in 2004, John Kerry, the Democratic Presidential candidate, discussed the imperative to increase achievement in mathematics. The need for high quality mathematics teachers and support for those teachers to improve teaching was identified as a cornerstone to improve education. Using a problem solving base to teach mathematics continues to be a reoccurring theme in improving mathematics achievement (Grugnetti & Jaquet, 2005; Martin & Bassok, 2005).

In 2004, Schoenfeld's publication *Math Wars*, described the ongoing debate in mathematics. This debate, between a formulaic and conceptual approach, focused on how best to increase student mathematics achievement. Neither the formulaic or conceptual approach has worked to improve mathematics achievement for all students. The middle ground between within this spectrum has been proposed as better suited to improve achievement. Students should be provided with some formulaic basics in mathematics, as well as the opportunity to make meaning through conceptual approaches. The inclusion of opportunities for students to develop theoretical thinking through active involvement in mathematics has been described as an essential attribute of mathematics education (Schmittau, 2004). The debate--with proponents firmly entrenched either on the formulaic or conceptual side of the spectrum--is one factor which has impeded the improvement of mathematics achievement (Lewis, 2005; Mervis, 2006; Schoenfeld, 2004). The development of a common ground somewhere between formulaic and conceptual understanding is imperative, underlying this is a belief by students that mathematical ability is innate.

Curriculum changes in mathematics at the high school level should be a reflection of the changes in technical knowledge (Taylor, 2006). The curriculum must support an increasing technological society and the increase of students matriculating to college. Participation of students in their mathematics education, regardless of the approach in the curriculum, is required for increased mathematics achievement. The ongoing debate over curriculum presented formulaically or conceptually has pitted mathematics educators against each other in striving to increase student achievement (Klein, 2007). A movement to provide education to mathematics students through a balanced approach incorporating both sides of the debate-- formulaic or conceptual--has been proposed as essential to increasing achievement (Cracolice, Deming, & Ehert, 2008; Davidson & Mitchell, 2008; Steen, 2007).

Mathematics has been a gatekeeper to college admission, through providing access to advanced mathematics for only select students (Buckley, 2010). High school teachers would select high-performing students for advanced mathematics classes--condemning the under-performing students to lower-level, non-college preparatory mathematics classes. As high school curriculum is redesigned or modified to better serve poor performing students, often the outcome is the same, with mathematics still serving as a gatekeeper for meeting college admission requirements. Interestingly, high school mathematics grade point average along with ACT mathematics scores, have been found--through a quantitative study by LeBeau, Harwell, Monson, Dupuis, Medhanie and Post (2012)--to have a significant impact on students completing college degrees in science, technology, engineering or mathematics (STEM) in college, regardless of high school mathematics curriculum.

Responding to recommendations for action from numerous reports, including previously mentioned NRC and NCTM reports (Reyes & Reyes, 2011; Woodward, 2004), mathematics curriculum has changed, often not to the extent articulated in the reports. One such action is to require four years of high school mathematics for all students, resulting in an unintended consequence of increasing the shortage of qualified mathematics teachers at the secondary level (Kelly, 2010). High schools serving high poverty or minority populations experience the teacher shortage more acutely than other schools. Some high schools have partnered with local post-secondary institutions to develop programs that create opportunities for underserved high school students to progress to college level coursework in math and science while still in high school. High schools have also implemented student cohort programs to increase the completion of higher level mathematics courses (Parke & Keener, 2011).

Academic Achievement

As high school student populations become increasingly diverse, teachers find themselves increasingly challenged to meet the needs of the changing student body (Buckley, 2010; Stodolsky & Grossman, 2000). This issue is exacerbated for mathematics teachers. Many mathematics teachers see mathematics as a series of skills to be learned in a specific order. The topics covered in a mathematics classroom are often viewed as needing to be taught in a specified order, not allowing for students to progress through mathematics classes until the previous material has been mastered. This widely held view has hindered progress in improving mathematics achievement. Teachers must believe students are capable of learning and achieving in mathematics, expressing this belief in ways which students can identify with (Alper, Fendel, & Fraser, 1997; Smith, 2002; Stodolsky & Grossman, 2000; Lembke, Hampton, & Beyers, 2012). Students in school are continually evaluated on a multitude of evaluations, from standardized testing to daily quizzes and homework reviews provided by teachers throughout schools on a daily basis (Levine, 2002, p. 329). The constant evaluation can lead to fa*ilure spiral*--students falling short on one evaluation scale, may start falling short on other evaluations.

Districts and schools should be involved in the student academic achievement improvement process (Rothman, 2009), and must stress the importance of good teaching. Measuring academic progress is essential during the improvement process to determine further steps to be considered for curriculum refinement. During the improvement process, the district should provide support to the school which in turn supports the teacher-- including both internal and external-- as determined by the measurement process. It is imperative that teachers, schools and districts are held accountable for improvement to the academic achievement of students. In one account, support was found through the use of professional learning communities in a yearlong study by Huggins, Scheurich, and Morgan (2011). In this study, professional learning communities involved mathematics teachers, school leaders and the principal. The involvement of school leaders and the principal was important in supporting the process of reform in the classroom; and providing emphasis for implementation of the reform measures by the individual classroom; and providing emphasis for implementation of the reform measures by the individual classroom teachers (Rothman, 2009). Another approach was taken as described in a critique by Shiller (2009) in New York, where small high schools were opened in poor urban areas to improve student learning through building relationships between teachers and students. This critique found that small high schools should support teachers on how to build positive student-teacher relationships; size of the school did not create relationships in isolation. Additionally, having teachers walk through the community surrounding the school can increase understanding of the daily lives of students (Cancienne, 2009). Developing an understanding of the lives students live outside of school can increase the teacher’s capacity to provide support to students to increase the academic achievement level.

Mathematics achievement as reported in the Trends in International Mathematics and Science Study (TIMSS) reports United States students’ mathematics achievement has not significantly improved over time (Bybee & Kennedy, 2005; O’Neil, Abedi, Miyoshi, & Mastergeorge, 2005; Valverde & Schmidt, 1997). This result suggests past policies on mathematics curriculums are not providing the desired impact on student learning. Mathematics curriculum was not previously standardized throughout all schools and districts. Identification of curriculum standards to improve student learning and to standardize a focused curriculum throughout the country and in every state has been identified as a priority (Hart, & Martin, 2008). The focus on developing national standards has diverted attention from school level studies to determine what is needed to improve student mathematics achievement at the individual school level (Nathan, 1995).

Innovative, research-based practices, designed to improve student achievement at the local level could be lost through the focus on national standards.

Surprisingly, in O'Neil, Abedi, Miyoshi, & Mastergeorge (2005) study found student motivation was not a factor in the lack of increase on international assessments. In their study, high school students were randomly assigned into two groups; the first group received ten dollars per correct answer and the second group received no remuneration. A test was created from the international questions which had been publically released. No significant differences in student achievement were found between these two groups.

Underlying the need to improve mathematics achievement for secondary students is a shortage of qualified mathematics teachers (Chaudhuri, 2009; Fox, 2002; Khadaroo, 2008; Posamentier & Coppin, 2005). Mathematics teacher development-- encouraging more teachers to select the mathematics teaching field as well as providing ongoing support to mathematics teachers in classrooms-- is critical to improving student math achievement.

A focus on improved student achievement in mathematics, especially at the high school level, includes a focus on the identity of the students who create the gaps in achievement (Fisher, Frey & Lapp, 2011). An instructional practice used to improve student achievement for gap students—students who are identified as under-achieving based on racial or socio-economic background—include extended school time, either through an extended school day or school year. School attendance and student engagement in the classroom were identified as having an impact on improving student achievement.

Rural high school students have lower academic achievement than urban or suburban students (Reeves, 2012). One factor in the lower mathematics achievement of rural students could possibly be shortage of available advanced mathematics classes. Family socio-economic status and peer pressure were demonstrated to have an effect on the selection of math courses taken by students at the secondary level, with those of lower socio-economic status choosing to take less advanced mathematics. In a retrospective study by Post, Medhanie, Harwell, Norman, Dupris, Muchlinski, and Monson (2010), high school mathematics curriculum was found not to be related to the number of mathematics courses completed in college.

A common approach to improve mathematics achievement is to provide remediation within the school for struggling students (Bahr, 2010). The remedial approach can occur in both secondary and post-secondary settings. The differences in student achievement levels prior to remediation are often identical to those achievement levels after remediation, and the concept of remediation has negative connotations. If the focus of an academic mathematics improvement plan is remediation, rectifying the missing skills and mastery of those skills, students will remain behind. Time will have been spent on skills which should have been previously learned and not on acquiring skills commensurate with grade level standards. Successful remediation, provided as timely intervention developing improved comprehension and skills, improved academic achievement of students (Lembke, et al., 2012).

Students graduating from high school and persisting to pursue post-secondary education have been required to take remedial classes at the post-secondary level in increasing numbers (Gallard, Albritton, & Morgan, 2010). Students who are required to take remedial classes--which are not considered credit courses at the college level--in math, English, or both have a low rate of college degree completion. A delay of earning college credits, because of the remedial courses, is a contributing factor in the failure to complete college degrees. A study by Acherman-Chor, Alado, and Dutta Gupta (2003), in a predominately Hispanic university found no significant differences in students who failed college algebra and those who did not fail college algebra when examining students' background variables, including ethnicity and attitudes toward math. This finding suggests a shift in emphasis from examining student background characteristics to examining teacher behaviors and instructional practices in the classroom. Students taking a rigorous high school mathematics curriculum have a high probability of attending post-secondary education (Crosnoe, Lopez-Gonzalez, & Miller, 2004). Hispanic students, particularly Mexican-American, are underrepresented in taking advanced mathematics in high school, generating fewer opportunities for post-secondary education.

Standardized testing used to determine student achievement in high school mathematics can have unintended consequences on the student's perceived ability to do mathematics (Bahr, 2010; Boaler, 2003; Lembke, et al., 2010). Students who have worked to improve their mathematic skill level and successfully completed tasks provided by mathematics classroom instructors can take the standardized test and receive grades not reflective of their learning; resulting in a drop of math confidence. Standardized tests report student achievement level-- as compared to other students-- rather than reporting the increase in skills gained by students. Mathematics teachers can be exposed to a similar frustration. After teacher collaboration in the school to improve student mathematical understanding, scores can be returned from the standardized tests showing progress to grade level still has not been achieved by the student or the school. When receiving low standardized test scores, especially for highly supported student populations, motivation for student learning and teacher instruction can drop--with students and teachers wondering about the point of all their effort. Teachers and schools could become focused on test-taking skills rather than on the development of mathematical thinking and achievement (Boaler, 2003).

Parents want children to succeed in school (Ginsburg, Rashid, & English-Clarke, 2008; Shiller, 2009). Mathematics educators can harness the desire of parents to assist students in succeeding in mathematics by providing support to parents on how to engage students in mathematical discussions. Providing parents with resources to use with their children, highlighting the use of mathematics through jobs and the need in higher education, can assist in creating opportunities for parents to engage their children in mathematical talk; thus increasing student motivation to learn mathematics. The process of creating more supportive parents to increase the level of engagement of students can be achieved in schools who provide parents with mathematics lessons; thus deepening the parental understanding of the concepts under development in the classroom.

Instructional Practices

Smith (2002) identified four conditions for learning mathematics:

- Students cannot be afraid of mathematics.
- Students must believe mathematics can be done.
- Time for students to learn and process mathematics needs to be provided.
- Math needs to be understandable and interesting. (pp. 126-127).

The conditions for learning mathematics are the basis for creating an environment conducive to learning. Many times students are expected to mimic the activities and steps presented by the teacher without an understanding of why the process works. The *why* and the *how* of mathematics needs to be provided within the classroom to ensure that the student develops mathematically. This is not a process which occurs without a commitment of time. Students learn in different ways and process material at different speeds. Mathematics educators who are striving to improve students' achievement in mathematics should create classroom environments supporting the students with opportunity and time to learn.

“Out of the box experience” (Kitchen, DePree, Celedo’n-Pattichis, & Brinkeroff, 2007, p. xi) is a phrase commonly used by technology retailers describing how the technology must be consumer friendly and technology should work without major problems or it is often returned by the consumer. This same principle applies to mathematics education. Students’ initial experience with mathematics, or a new concept in mathematics, must be positive and free of major problems, the student may shut down—believing mathematics may be beyond their ability to comprehend. Students receiving support and motivation to continue to try either from the school environment or home environment in a timely manner can negate the negative “out of the box experience” (Lemke, et al., 2012). Mathematics anxiety-- student belief that math is difficult-- has frequently developed from negative experiences when learning mathematics (Allsop, et al., 2008; Kitchen, et al., 2007; “Overcoming math anxiety,” 2007; Smith, 2002).

Lessons from special education on managing students with math anxiety can be used to increase achievement for all students (Kozik, Cooney, Vinciguerra, Gradel, & Black, 2009; “Overcoming math anxiety,” 2007). Math anxiety can cause or be caused by problem solving struggles. At times, within special education inclusion classrooms; teachers assign students to work in groups to solve difficult or complex problems. Time is provided in class for the assigned groups of students to work on problems, creating the opportunity for peer assistance (Allsopp, et al., 2008; Lembke, et al, 2012; Smith, 2002). When this occurs in a co-teaching inclusion class, groups are able to get more immediate assistance in solving problems, therefore reducing anxiety levels. This creates opportunities for students to have positive experiences in mathematics. By providing time to learn as well as a probable reduction in negative experiences in mathematics, two of Smith's (2002) four conditions for learning math are met.

Appreciative Inquiry is an applied research consisting of four stages: discovering the best of what is, dream of what could be, design what should be, and destiny creating what will be (Cooperrider & Whitney, 2005). Appreciative Inquiry has been used to study ways in which co-teaching (a regular education and special education teacher working to jointly instruct a class) works within an urban high school (Kozik, Cooney, Vinciguerra, Gradel, & Black, 2009). In this study, three factors were found to have positively impacted the implementation of effective special education inclusion programs using co-teaching within secondary schools. The three factors included: time for teacher collaboration; a belief that all students can learn and; administrative support of inclusion efforts. This study on inclusion at the secondary level supports three of the four identifiers of effective curriculum as defined by Alper, Fendel and Fraser (1997):

- The curriculum needs to make students comfortable with the material.
- Personal validation of learning must be provided to students.
- Active involvement in learning must be provided for all students.

The fourth identifier of effective mathematics curriculum identified by Alper, Fendel & Fraser (1997)-- reasons for doing problems--was verified by Haung, Normandia, and Greer (2005) with a communication study which examined teacher and student talk within secondary mathematics classrooms. This Haung, Normandia, and Greer found that teachers presented concepts at higher levels than students communicated back. The researchers identified students who responded with practical level knowledge based communication, which demonstrated that the teacher had provided reasons to students for doing problems.

Students with learning disabilities participate in mathematics classes alongside regular education students, creating challenges or opportunities for teachers, depending on the teacher's viewpoint (Miller & Mercer, 1997). Students with diagnosed mathematics learning disabilities tend to be passive learners, which translates into a dependence on the teacher and other external sources. The pattern of low achievement levels in mathematics will continue until reform in the instructional process is achieved in the mathematics classroom. Principals and other school leaders should assist with providing teachers training on the latest mathematics teaching trends and monitor the implementation in the classroom (Checkley, 2006).

Special education and general education mathematics teachers were surveyed with regard to their specific instructional practices used in the mathematics classroom (Maccini & Gagnon, 2006). Instructional practices found effective in mathematics classes include organizers, tactile materials, using technology, cueing, color coding, and various tutoring strategies. Modifications provided to special education students included decreased assignments in addition to extended time for completion of assignments, activities, and tests. These modifications and instructional practices could be of use with all students who struggle in mathematics. Teachers' use of appropriate instructional modifications was found to be dependent on the number of teaching methods classes taken, as well as the certification of the teacher. Mathematics teachers tended to use fewer modifications or accommodations than those used by certified special education teachers. This survey provided a snapshot of the lack of methods classes taken by both general and special education teachers on modifications and accommodations provided to special needs students to support academic achievement in mathematics. The necessity to create opportunities for both the special education and the general education teachers to collaborate to improve mathematics education for all students was identified in this study. An additional approach identified was to consider requiring dual certifications in teaching mathematics and special education.

Teaching both special education and general education students within the same classroom has many perceived hurdles (Cole & Wasburn-Moses, 2010). Special education teachers tend to present mathematics to students in a formalistic manner by providing direct instruction. Mathematics credentialed teachers encourage students using a conceptual approach to teaching mathematics. The necessity of involving students in creating meaning from mathematics is important in developing higher level thinking skills; increasing mathematics achievement of students. All students could benefit from teachers who use a formulaic and conceptual approach when teaching math. The middle ground between the two approaches may work to create the best opportunities for increased mathematical achievement (Schoenfeld, 2004).

Concrete, representational, abstract (CRA) is an instructional strategy developed for special education shown to be effective within mainstream mathematics classes as well (Miller & Hudson, 2007; Strom, 2012; Witzel, 2005). In the CRA instructional model, students start with concrete objects which can be manipulated physically. The second phase of this model requires students to work similar problems using representations of the concrete objects to develop connections between the concrete objects and the representation of the object. The final phase requires that students work abstractly on similar problems, without dependence on concrete objects or representations. Formulaic mathematics is supported through the concrete and representation stages of the instructional process, moving towards conceptual mathematics supported by the abstract stage of instruction.

To increase mathematics achievement five interdependent strands were proposed by Kettlewell and Henry (2009):

- Conceptual understanding.
- Procedural fluency.
- Strategic competence.
- Adaptive reasoning.
- Productive discipline.

The above strands were critical to implementing an approach to all mathematics instruction. Both conceptual and formulistic approaches should use the five strands, along with students ability in applying learned mathematics to new situations, to improve mathematics instructional practice.

Teacher instructional practices have been divided into mastery goal oriented and achievement goal oriented practices (Deemer, 2004). Mastery instructional practices are associated with greater effort which then leads to greater rewards, and opportunity to increase student learning. Achievement goal orientation creates an environment where one student's work is judged against another students' work, instead of concept attainment, and failure to achieve can lower student self-belief to do math (Boaler, 2003). In a quantitative study by Deemer (2004) where science classrooms were examined, differences were found when comparing what is occurring in high school versus elementary, middle and college classrooms-- students and teachers have different perceptions on the mastery or achievement orientation of the classrooms. This difference in perception between students and teachers is that teachers believed more mastery goals are used, while students believe achievement goals are used in the instructional process. Checkley (2006) found similar differences between student and teacher perception in the mathematics classroom, the students' belief in their ability to do math might be reduced, compromising one of the four conditions identified as needed to learn math (Smith, 2002).

Teachers who demonstrate an autonomy-support motivation in instruction have been identified as having a nurture competence for students and as being student-centered (Manouchehri, 2004). Teachers demonstrating a controlling style of motivation in instruction have been identified as being just what the label implies, controlling of the activities and interactions taking place in the classroom. Manouchehri's (2004) research found that autonomy-support motivational teachers (student centered) were better at implementing reforms to the curriculum in the mathematics classroom than those who demonstrate controlling motivation teachers (teacher centered). Classroom activities are viewed as a reflection of the teachers' motivational style. Classrooms that were observed in Manouchehri's study using worksheets and exercises were determined to be led by teachers with controlling motivational style and were as less effective. Concurring with Smith's (2002) conditions for learning mathematics, autonomy-support motivational teachers provide students with time and support needed to learn mathematics, meeting two of the four conditions.

It is imperative for mathematics educators to adapt to the changing student population within their classrooms (Osisioma, Kiluva-Ndunda, & Van Sickle, 2008; Stodolsky & Grossman, 2000). This change in student demographics is based on an increase in cultural diversity, changes in economic conditions, and increases of technology. Teachers who adapt to the demographic change and believe students can learn were viewed as successful in supporting students in learning mathematics. Teachers who view diversity as a disability tend to have lower rates of success in supporting student mathematical learning. Reinventing classrooms to support student achievement can provide all students the opportunity and time to learn regardless of the diversity present in the classroom. Respecting diversity within the student body includes gender differences as well, thus teachers should implement practices that support mathematics achievement for all students. (Norman, 1988; Watt, Shapka, Morris, Durick, Keating, & Eccles, 2012). Teachers, who recommend specific students for placement in advanced academic classes because of the teacher's perception of the student's capability, can be correlated to gender, ethnic background and social status of the student (Barber, & Torney-Purta, 2008).

Teacher behaviors are important to creating a learning environment in the classroom which is conducive of all students learning mathematics (Kukla-Acevedo, 2009). Student achievement has not been consistently related to particular teacher characteristics. Teacher behaviors and characteristics vary based on years of teaching experience and the needs of the students. Translated into action, recruitment of mathematics teachers for a particular district, school, or classroom to improve student achievement is not dependent upon finding teachers with select behaviors and characteristics. Teacher behaviors and classroom practices may matter more than the certification and years of experience of the teacher (Aslam, & Kingdon, 2011).

Instructional practices based on clear communication to students impact student achievement based on surveys given to ninth grade students (Mottet, Garza, Beebe, Houser, Jurrells, & Furler, 2008). Students value clarity of presentation and relevant content instruction in mathematics. Communication in mathematics teaching is important in increasing mathematical achievement of students (Danesi, 2007). Solving word problems involves students being taught and learning what the words used in the problems mean mathematically. Translating the verbiage in a word problem into a mathematical problem is a skill which should be developed in students and involves ongoing communication from the teacher to ensure student understanding is developed. The use of technology along with practical applications can improve the process of deciphering word problems and improve overall mathematics achievement for students (Bellamy, & Mativo, 2010).

An extensive list of instructional programs and approaches reported to improve mathematics achievement including:

- Mathematics Dynamic Assessment – Allsopp, Kyger, Lovin, Gerretson, Carson, & Ray (2008)
- Authentic Instruction – Dennis, & O'Hair (2010)
- Reciprocal Teaching – Hartman (1994)
- Memorable Menu Math – Thrift & Ortiz (2007)
- Kinesthetic Activities – Juraschek (1990)
- Connecting Education and Careers – Williams (2000)
- Supermath – Pogrow (2004)
- University of Chicago school mathematics project - Usiskin (1993)
- Accelerated Math – Cavanagh (2008)
- Peer Assisted Learning Strategies – Baker, Gersten, Dimino & Griffiths (2004)

This list does not include all instructional approaches or programs which were promoted as improving mathematical achievement. These programs and similar programs were each presented as *the* method to improve student mathematics achievement. Each program had strengths, worked for some students, but not for *all* students.

Conclusion

Throughout the literature reviewed, student voice on mathematics achievement is under-represented (DeFur & Korinek, 2009). Student mathematics achievement from the adult perspective is prevalent among mathematics education researchers. Instructional practices and the emphasis of those practices have shifted from formulaic to conceptual and back again (Schoenfeld, 2004). Monitoring of student academic achievement at district, school and classroom level is critical to improve academic achievement of students (Rothman, 2009). The curriculum and instructional practices of mathematics education have been studied and findings published without the desired effect of significantly increasing student mathematics achievement as shown with TIMSS and ACT (American College Testing, 2013; Bybee & Kennedy, 2005; O'Neil, Abedi, Miyoshi, & Mastergeorge, 2005; Valverde & Schmidt, 1997). Research in special education mathematics learning and teaching provide insights into best practices to support mathematics achievement of struggling students (Allsopp, et al., 2008; Kozik, et al., 2009; Lembke, et al., 2012; "Overcoming math anxiety," 2007).

CHAPTER III

METHODOLOGY

Introduction

The purpose of this qualitative study was to explore student perspective of high school mathematics instruction using the student voices. This study identifies teacher behaviors and actions that make mathematics achievement possible for the consumers of instruction—the students. In mathematics there is an ongoing debate on whether a conceptual approach or a formulaic approach is the best instructional approach for students to learn mathematics (Lewis, 2005; Mervis, 2006; Schoenfeld, 2004). Mathematical achievement has been found to include a strong base of mathematical facts and the use of problem-solving strategies to solve new and different types of problems. Trends in International Mathematics and Science Study (TIMSS) shows the mathematical achievement of high school students in the United States has not improved over time (Bybee & Kennedy, 2005; Valverde & Schmidt, 1997). Four essential conditions for increasing student learning of mathematics (Alper et al.,1997; Smith 2002) are:

- Curriculum needs to be understandable and interesting.
- Personal validation of progress without anxiety.
- Active engagement and student belief math can be done.

- Time and reason for students to learn provided.

Identification of teacher behaviors and actions currently working to improve mathematics achievement in the secondary classroom--from the student's perspective--is an underrepresented view within the literature on mathematics education. Given the plethora of mathematics research, one would wonder why students have not been directly involved in providing input about what works to improve academic achievement in mathematics.

As an educator who taught mathematics and supervised mathematics teachers—both formally as a principal and informally as a mathematics department chair-- I have discovered that mathematics education research traditionally focuses on what *is not* working within the classroom. Popular media—newspapers, television, internet—report schools as failing based on standardized test scores such as the American College Test (ACT) (2013) which showed an increase in the average national score from 2009 to 2013 of two-tenths of a point. The same media outlets are the first to report on any negative occurrences in the schools. Due to the void of strengths-based literature on what students identify as good instructional behaviors in mathematics, it is important to interview students about their high school math experience to discover what *is* working. As educators it is critical that we listen to student voice to build a strong base in improving student mathematics achievement.

Research Questions

Since the emphasis in mathematics instruction has continually shifted between developing conceptual understanding and formulaic understanding (Lewis, 2005; Mervis, 2006; Schoenfeld, 2004), the ongoing question of why students continue to struggle to achieve mathematically continues to be of concern. A missing piece of research is student perspectives of what teachers do instructionally to assist students in achieving mathematically. This study will identify student perceptions on how teacher instructional behaviors and actions in mathematics classrooms support mathematical achievement. Regardless, if the approach used by the teacher in the classroom is conceptual, formalistic or a combination of both, student perception of what works in a classroom can assist in refining instruction provided to increase mathematics achievement (Davison & Mitchell, 2008; Steen, 2007; Taylor, 2006).

The research question for this study is the result of my literature review, as well as my personal experience as a mathematics educator and principal at the high school level. My experience also includes work as an adjunct professor in mathematics and instructional leadership. The breadth of experience in both the high school and colligate level provides opportunities to engage in informal discussions with many different adults from various occupations over the course of the last three decades about experiences in math education. Adults from various occupations placed themselves along a continuum of mathematical aptitude. These individuals—in informal conversations—usually perceived themselves as not having mathematical aptitude, which did not appear to be dependent upon the age of the individual. Adults shared stories about teacher behaviors and actions, which contributed to their belief about their own mathematical ability, leading to my research question:

- What are the teacher behaviors and actions which impact student mathematical achievement, as perceived by students?

Using a qualitative approach creates the opportunity for positive, strengths-based conclusions to this research question. Positive teacher behaviors and actions as identified by students should improve the mathematics experience of other students, once replicated in other classrooms, leading to an increase in students believing they possess mathematical aptitude (Coleman, 2009; Miller, & Greene, 1996; Stolp, 2005). If increased numbers of students perceive themselves as mathematically capable, numbers of students pursuing post-secondary education in mathematics related fields could increase. This belief about mathematical ability can contribute to stopping the failure spiral identified by Levine (2002).

Research Location

This study focused on university student perspectives of their high school mathematics experiences. This midsized southeastern state university was not considered a top-tier university during the time of this study; however it is highly respected within the surrounding area. The service area of the university consists of primarily rural Appalachian counties. The university is predominately Caucasian, which reflects the population of the university's service area.

Research Sample

The student voices are used in this qualitative study to explore student perceptions of secondary mathematics classrooms (Casey, 1995). Voice of participants provides interpretation of what was experienced during their high school math career. Understanding student perceptions occurring within the mathematics classroom provides insight into what has worked to improve academics.

Saldana (Saldana, 2011, p. 34) explains that there are adequate participant interviews when saturation has been reached. Interview participant saturation is described as an ongoing interview process until new information is no longer provided through the inclusion of new participants. All participants in the interviews for this study expressed the desire for the same instructional strategies to support their learning of mathematics, supporting saturation having been met. Student voice provides understanding of the classroom experience which could then be used to improved engagement of students in the classroom (DeFur & Korinek, 2009).

My data collection began during the summer one session of 2013, at the southeastern university, email requests for permission to survey students were sent to all math professors. Subsequently, surveyed students were queried about participating in the interview portion of this study. (See appendix A.) A total of 10 classes were surveyed including:

- one pre-algebra
- two introductory algebra
- one algebra two
- one mathematics with applications
- one trigonometry
- two math for middle and elementary teachers (one of which was at a satellite location for the main campus)
- one calculus with applications for business and economics
- one calculus three

Pre-algebra, introductory algebra and algebra two are considered remedial mathematics classes at the collegiate level, and the remaining six classes from the list above are considered college level classes. One hundred-eleven surveys were given to students in the 10 classes with 110 completed. The survey included basic demographic information about the student and their mathematic background. (See appendix B.) Information gathered included:

- name of graduation high school
- year graduated
- student perception of high school state standardized test scores

- math classes enrolled in high school
- student overall high school GPA
- student high school math GPA
- first math course enrolled in at University
- semester, year, and grade of first college math class
- race
- major
- willingness to participate in an interview

Seventy five of the students who filled out the survey declined to be interviewed. The remaining 35 students who filled out surveys completed the contact information on the survey signifying they would be willing to be contacted for a possible interview. Of the 35 who volunteered to be interviewed, 11 responded positively to interview requests. Those interviewed represented a range of students coming from all levels of math classes visited.

Study Participants' High School Mathematics Opposed to College Math Placement

In the demographic survey, information was requested about their mathematics classes taken during high school, along with the first math class taken in college. Percentages were calculated using the 105 surveys with high school and college math classes both listed. Not all participants provided information on both high school and first college class taken.

During the summer session, when the surveys were completed by students enrolled in math classes at the university, 13 students identified themselves as having attended schools at the secondary level in various Middle Eastern countries. Table 3.2 contains the same information as table 3.1 without including the 13 students who attended secondary schools in the Middle East. The exclusion of these international students was utilized to better highlight the survey results comparing high school classes taken with college mathematics placement for students who attended high school in the United States.

This data was consolidated from tables included in appendix E. Collegiate classes which study participants identified as the first taken at the colligate level were divided into remedial and college level classes. Remedial classes are not considered as transferable outside the institution, while the colligate classes are indeed transferrable. High school mathematics classes were consolidated into three groups: study participants who did not complete the algebra I, geometry, and algebra II college preparatory sequence; those who completed the sequence; and study participants who took courses beyond the sequence. Study participants who did not complete the sequence were identified from the surveys as those who reported completing geometry or lower levels of high school mathematics. Study participants who completed the college preparatory sequence were identified as having reported taken algebra II as their highest level high

Table 3.1

Condensed United States and Middle East participants' initial college math course

High school classes	Number of participants	Starting colligate course (%)	
		Remedial	college level
Sequence not completed	31	20.00	9.52
Sequence completed	33	20.95	10.48
Sequenced exceeded	41	18.10	20.95
Totals	105	59.05	40.95

Table 3.2

Condensed United States participants' initial college math course

High school classes	Number of participants	Starting colligate course (%)	
		Remedial	college level
Sequence not completed	25	17.39	9.78
Sequence completed	31	21.74	11.96
Sequenced exceeded	36	16.30	22.82
Totals	92	55.43	44.56

school mathematics class. Study participants reported taking pre-calculus/trigonometry or higher level classes were identified as exceeding the college preparatory sequence.

This critical information presented in tables 3.1 and table 3.2 displays students in the sample who complete the college preparatory sequence or lower level mathematics classes in high school only 21 participants out of the 105 surveyed are able to take college level mathematics without having remedial mathematics classes first. If high school students have exceeded the college preparatory sequence only 22 participants out of the 105 surveyed are able to take college level mathematics without having remedial mathematics classes first. Overall, of the survey participants who completed high school in the United States, 55.43% had to take a remedial level math class in college.

High schools within the universities service area have begun to offer a transitional math class, as a fourth year high school math class to students not scoring well on the standardized college entrance exams. In this particular study, only two participants identified themselves as having taken a transitional math class while in high school. Both of these participants were included in the study, but the transitional math classes were not included. One of the two participants began in pre-algebra and the other in introductory algebra, which are both remedial math classes at the collegiate level.

Interviews

In this study, college students were interviewed about their perceptions of teacher behaviors and actions influencing the student's mathematical achievement while in high school. During interviews, participants were able to openly share experiences from high school mathematics based on their recollections. Students were interviewed about how perceived teacher behaviors and actions supported their mathematics achievement.

Informed consent, including a confidentiality clause, was provided to the participant prior to the interview. (See appendices C and D.) Each interview varied from approximately 30 to 90 minutes in length. The participant interviews were recorded using a digital recorder and saved to a pass-word protected computer for later transcription. Participants agreed to be contacted with follow-up questions for clarification and validation at a later date (Creswell & Miller, 2000). Each interview was transcribed, using pseudonyms for participant, teacher, school and district names--or any other personally identifiable information that surfaced during the interview process. All documents—including transcriptions—obtained during this study will be kept in a locked cabinet in the researcher's home for a period of five years, after which all information related to the study will be destroyed.

Interviews were conducted in a mutually agreed upon location, usually a conference room located within the College of Education. The location of the interviews occurring away from the main math building ensured anonymity. The interviews were scheduled at times convenient for the participants.

The analysis of interview transcripts began with coding for themes about math instruction that helps or hinders students from understanding. Once interview recordings were transcribed, the transcripts were subsequently read for accuracy while listening to the recordings. The transcripts were once again read while focusing on recurring themes. Six themes emerged once transcripts were color coded according to these recurring themes. The information gained through the color coding was again modified upon separating the transcripts into quotes representing the thematic groupings. Attempting to place the coded transcript quotes into the identified themes revealed the first identified themes overlapped and should be condensed into three themes.

- Teachers provide ongoing support to student learning
- Teachers use teaching tools which included technology; helpful or not to student learning
- Teacher instruction that is an impediment to student learning

These three themes supported participants' descriptions shared throughout the interview process. Participants described teacher classroom behaviors which supported or impeded learning. Although their vocabulary often varied, interviewees detailed similar experiences to other participant's descriptions found throughout the transcripts. The similarity of the experiences became apparent during the sorting and coding process.

Student Voices on High School Math

Interview transcripts provide narratives of the participants' experience of their high school mathematics classes. The transcripts, background information on the participant, and the publically available data from the participant's high school created the opportunity for triangulation (Creswell, & Miller, 2000). Participants were encouraged through the interview process to provide detail on teacher behaviors and actions supporting the participant's belief in their ability to do mathematics or the mathematic problems.

Comparison of student perception to actual school test scores. Survey participants were requested to report on the achievement of their high schools on state standardized testing as part of the triangulation process (Creswell & Miller, 2000). Survey participants were provided with the choice of high, average or low to select from based on their recollection or perception. State departments of education were used to locate the actual rankings of the schools of attendance for each participant. Some of the schools were not located in the same state as the university. Actual scores form 2011/2012 state standardized rankings are on the horizontal labels as shown in table 3.3, with the survey participants' perception of test scores on the vertical labels. All survey participants are included.

Table 3.3

Survey participants reported state test score rankings versus actual state rankings

Participant reported	Number of participants	Actual 2011/2012 state test score rankings (%)				
		High	Average	Low	No Score	School Closed
High	23	1.82	3.64	6.36	9.10	
Average	54	3.64	3.64	23.64	17.27	2.73
Low	18	1.82	1.82	9.10	1.82	1.82
No score	15		1.82	7.27	3.64	0.91

Table 3.3 shows most survey participants in the study rated the performance of their high school in state standardized mathematics testing as higher than the school actually scored. Twenty-three percent of the college students surveyed believed the high schools attended scored in the average range on state mathematics testing when the actual scores were in the low range.

Interview participants. The eleven interview participants represented various demographics reflective of the 110 surveyed students. Ten of the interview participants were recent high school graduates, with the 11th participant having earned a general education diploma (GED). Two of the participants attended private high schools, one graduated from an online high school, one graduated from an urban high school, and the other six participants reported attending rural high schools, which varied in student population. Gender was represented with six female and five male participants. One African-American and one Native American participant were interviewed during the study, with the remaining participants reporting as Caucasian. This sample is fairly representative of the race of the survey participants and service area of the university. The range and variety of participants provided a range of beliefs about individual ability to do mathematics. Interviewees declared majors as follows:

- One in mathematics
- One in physics
- Three in nursing or sports medicine
- One in network security
- One in occupational safety
- One in education
- One in criminal justice
- One in livestock production

The participant pool was fairly evenly divided with five participants expressing the belief that they were competent in mathematics and six expressing a lack of competence in mathematics.

This study explores teacher behaviors and actions which can impact student belief, confidence and perception of the student's ability to be successful mathematics

(Barber & Torney-Purta, 2008; Kitchen et al., 2007; "Overcoming math anxiety," 2007; Smith, 2002). Participants responded to open-ended questions about their experiences in the mathematics classroom. In addition, participants were asked a variety of follow-up questions to elaborate on how their math experiences influenced their personal beliefs about their mathematics ability during high school, and in the future.

Interview Questions

Main question:

- Tell me about your math experience in high school.
    - What made the experience good, were there years it went better than others and why?
    - What has had the biggest impact on learning math for you personally, and why?

Follow up questions:

1. Tell me more about what the teacher did in class that made it better or worse for you to learn mathematics?
2. What happened if you did not understand your math homework?
    a. What happened if you did not understand the math classwork?
3. What did the math teacher do if you or others in class were not working?
    a. How did the teacher's actions impact you?

4. What types of choices were you given about activities in math class?
    a. How did the teacher's behavior impact your choices?
5. During your math class, did the teacher provide time to work on your math assignment?
    a. What was the teacher's response if you asked the teacher a question?
        i. What was the teacher's response if someone else asked the teacher a question?
        ii. If the teacher responded differently, what were the differences?
    b. What were the teacher's actions and behaviors during seatwork time?
6. How did your teacher's behaviors and actions influence your belief about your ability to do mathematics?
7. How did the math teacher structure class time on a typical day?
    a. Was the class structure ever varied from the typical day?
    b. Why do you think the teacher altered the structure?
    c. How did that impact your ability to learn math?
    d. How do you think that impacted other student's ability to learn math?
8. How did the teacher present new topics in math?
    a. What did the teacher do that made you feel you could master the material?
9. What did the teacher do if you asked a question or did not ask questions?
10. Were there activities outside of your math class that impacted your ability to learn math?

    a. What were they and how did they impact you?

11. What made the difference between the best and worst math teachers that you had in high school?
    a. How did they make you feel about math and your ability to do math?
12. Is there anything else you would like tell me about your high school math experience we have not already discussed?

Subjectivity and Trustworthiness

Performance of the survey participants' high school in state standardized testing was usually lower than the participant rated the school, supporting the interview participants' expressed beliefs that positive experiences in learning mathematics at the secondary level occurred. Interview participants were demographically representative of the survey population. Interviews were conducted by asking an open ended question which asked participants to describe their high school math experience, with clarifying and reflective questions asked throughout the interviews. Four of the interviewees' initial math class in college was considered remedial while the remaining seven initially enrolled in college level math. Since 55.43% of the surveyed students started in remedial math, the interviewees' remedial rate was only 36.36%, translating to a higher level of college entry mathematics. The interviewees demonstrated success with understanding and applying secondary level mathematics to be able to test out of remedial mathematics either through the college admission test or math placement test given at the university.

Participants having demonstrated knowledge allowing for a higher percent of students starting in college math demonstrate the participant having gained math knowledge during high school. Saturation having been reached during the interview process as previously stated provide for two of the three supports for triangulation. The third support is students rating high school performance on state standardized testing as higher than the schools actually scored. Triangulation provides for trustworthiness of the results (Cresswell & Miller, 2000).

While working as a high school math teacher, my approach was to involve students in mathematics which also created a noisy room environment for learning. Once I became a high school administrator, visiting a variety of math classrooms and teachers, the realization of different learning environments being effective to improve mathematics teaching and learning became evident. I am admittedly bias toward active student involvement in mathematics learning, which is fortunately supported by research (Alper et al., 1997; Smith, 2002). Awareness of my bias allowed for the minimization of my personal perspective impact on this study. For example, ability grouping is presented in the participants'data as a method of improving mathematical achievement discussed by interviewees. The details of the findings are including in Chapter IV of this dissertation. My personal bias would be to avoid ability grouped classes, such as low, medium and high level classes of the same subject; the beliefs of the participants supported its use and included in this study despite my belief about ability grouping.

Conclusion

In this study college and career readiness measures identify only 34% in 2009 of high school students graduating ready for life after high school in the universities service area (KDE, 2013). Survey participants have reported 55.43% began by having to take remedial levels of mathematics in college. Approximately one quarter of the survey participants reported their high school as performing higher on standardized state tests than the schools actually scored. Mathematics education has shifted emphasis from conceptual to formulaic and back again without significantly improving student achievement in mathematics (Reyes & Reyes, 2011; Woodward, 2004). Interview participants provide a window into the student perception of the high school math experience. The voice of the interview participants can inform instruction that has increased or impeded mathematics achievement in high school classrooms.

Thematic analysis was used to discover commonalities in teacher behaviors identified by participants impacting perception of math ability. These themes were used to highlight how teachers increase math achievement as well as behaviors that may have limited the participants' math achievement. These descriptions can inform further research on how teachers can better meet the needs of students in learning mathematics.

In addition, the participants' descriptions serve to highlight the unintentional consequences of teacher behaviors in reducing student belief in the ability to learn mathematics. Student belief in their ability to learn math has been identified as a contributing factor to math achievement (Smith, 2002). Math achievement has stagnated as shown by ACT and TIMSS scores. College and career readiness are a focus in the Common Core Standards, with the state the southeastern university is located reporting only 34% in 2009 of high school graduates as college or career ready (Kentucky Department of Education [KDE], 2013).

CHAPTER IV

INTERVIEW RESULTS

Introduction

High school graduation requirements currently include taking and passing algebra I, geometry, and algebra II. The adoption of the Core Curriculum state standards (2012) mandated the curriculum increase. One would think that requiring higher levels of curriculum in mathematics would lead to an increase in levels of mathematics achievement as reported by standardized tests. American College Testing (ACT) reports the national average ACT math score in 2013 was 20.9 while in 2009 the average national score was 21.0 (ACT, 2013). The same report shows mathematics scores for this state where this study was conducted as having minimally increased from 19.0 in 2009 to 19.2 in 2013. ACT reports the college readiness for college mathematics as a score of 22, with a maximum composite score of 36. One may ask why the scores remained stagnant over time when curricular requirements in mathematics for high school graduation increased. The purpose of this qualitative study is to explore from the student's perspective what teacher behaviors and actions contribute to effective mathematics instruction. A summary of findings is available in appendix F, along with a comparison of Comparison of regular math education research with special education research.

Student Voices on High School Math

Historically, a typical day in a mathematics classroom at the high school level is identified by spending time reviewing homework, followed by a lecture introducing new material, and any class time that may have been remaining is used for students to work on homework. Over the past few decades little has changed from what has been observed in high school mathematics classrooms (Hayes, 1992; Woodward, 2004). For example, the typical day in a math classroom was described by the study participants as present in classrooms where they were learning as well as in classrooms where they did not believe they were learning mathematics, just as participant Emma described:

> The first part [of class] we went over homework from like the previous time we were in there. And then we went over answering questions or clearing things up. Or if she had to re-teach something on a topic that was unclear. And then they [the teacher] went into something new and then depending on the time… They gave us in-class time to finish the homework or do the homework for that night or sometimes you just kind of pack up to stop and leave for your next class.

All interview participants described a typical structure for the day in a high school mathematics classroom in a similar manner regardless of whether they believed they were learning. Since ACT scores have not significantly improved (ACT, 2013), a deeper in-depth look at student perceptions of high school mathematics experiences is warranted to identify teacher behaviors and actions which supported student learning of mathematics in this typical classroom structure (Hays 1992; Woodward, 2004).

Student Voices on High School Math

This study identified three overarching themes from participant interviews:

- Providing ongoing support of student learning
- Use of teaching tools including technology
- Impediments to learning

These themes are interrelated forming a framework from interview participant high school mathematics class descriptions.

Providing Ongoing Support of Student Learning

Providing ongoing support by teachers for student learning is essential and supported by research (Alper et al., 1997; Smith, 2002). Alper et al. and Smith found active student engagement within the learning process is critical for student learning. In addition, the use of mathematics vocabulary by teachers could interfere with student understanding of concepts when presented during the instruction of new material was described by one of the participants, Owen "Instead of [using] layman's terms and instead of breaking it down in simple [language], simplifying it [the new concept], it was just put into a way were I couldn't understand it." Another participant, Emma, explained how teachers could break down vocabulary to help their students' comprehension of material. "They were like here's this word and then they tried out a definition and they would give us examples and say this is what it is, and then you were, okay it clicks." Mathematics vocabulary was identified as both contributing to learning mathematics and an impediment to learning mathematics depending on the methodology used by the teacher to define the vocabulary. When teachers took the time to define and explain the definitions using nonmathematical terms to introduce the mathematical vocabulary, students reported increased understanding of new vocabulary. Fisher and Blachowicz (2013, pp. 43-44) identify four characteristics of effective vocabulary instruction in mathematics:

- Link physical manipulation to language
- Talk through explanations
- Include visual representations
- Teach morphemes

Owen's and Emma's statements supported these four characteristics.

Most participants in this study identified having the ability to see and hear the teachers thought process while example problems were worked out for the class as assisting in their learning process. Similarly, research reports that by teaching the *how* and the *why* of solving problems is central to increasing student understanding of mathematics (Bellamy & Mativo, 2010; Boaler, 2003). Participant Ethan identified this type of teaching behavior by his math class teachers as "chalk talk". When asked to explain what was meant by "chalk talk" Ethan provided the following:

> [Chalk talk is] where everything he [the teacher] did was up on the chalkboard. So there was never anything like PowerPoints or anything like that, everything that you would do, every problem would be worked on the chalkboard. He would have

> the whole class up working problems on the chalkboard as sort of his way of teaching. Which, I love that style of teaching, it's the best. I think it's [chalk talk] an awesome way to learn… It was just sort of a really interesting way to look at math, and I think that way [chalk talk] of looking at math instead of looking at it just strictly straight ahead from out of the textbook, his little loopholes and stuff that he has, and all his other little ways made learning calculus easier.

"Chalk talk" was described by Ethan as the teacher demonstrating and explaining problems step-by-step on the board along with providing opportunities for students to work similar problems out. Participant Emma supported the instruction of her math teachers using a similar teaching process. Emma describes the instruction of one of her more effective teachers, "She would do handwritten notes, examples and stuff, and we would copy it down." According to interview participants, teachers should go through problems, both writing the problem out while explaining the *how* and the *why* in a step-by-step manner. Additional methods that can provide deeper understanding for students should be presented by teachers during this process of writing ut the problems-- Ethan described these helpful methods as "his little loopholes." Implementation of the Common Core Standards calls for both conceptual and formulaic understanding to be supported and taught to increase rigor within the curriculum (Common core state standards initiative, 2014).

The word "elaborating" was used by participant Jacob to describe instruction he needed from teachers. When asked to explain what he meant by teachers who elaborate, Jacob stated, “By elaborating I mean going in and explaining the steps, step-by-step what they’re doing, waiting a short amount of time for questions in between each step of the problem, and making sure students know it.” Interview participants believe the *how* and *why* of problem solution is important to assisting their understanding. Participants want to know the step-by-step process of the problem solution and believe it is necessary for teachers to ensure that their students understand the steps, processing the teacher’s presentation, before moving on to the next step. Mervis (2006) and Schoenfeld (2004) support teaching math from a middle ground between formulaic and conceptual approaches, supporting the interview participants need to know both *how* and *why*.

Participant Owen also spent time describing the necessity of teachers breaking down material and assisting students in thinking through the material presented. Owen believes that “Spoon feeding” the new material to students assists in students comprehending mathematics, and the mathematics vocabulary presented. “Spoon feeding” was defined by Owen as “kind of nudging them [the students] along the way instead just slamming it [the new material presented] down all at once.” Another participant, Evelyn, stated “Just as long as I could see her [teacher] visibly do it [problem] and see where her thinking process went, I did all right. But if I didn’t get her thinking process, I was just screwed.” Kitchen, DePree, Celedon-Pattichis, and Brinkerhoff (2007) compare this frustration level to using new technology. Customers purchasing new technology expect to be able to turn on the device and have it work, or the device could be returned for one that works upon starting it up. This concept, when applied to mathematics learning and education, is similar according to Kitchen et al. (2007). Students learning math need to be able to understand and do the mathematics presented without encountering major problems or frustrations with the mathematics, or learners may put mathematics back on the shelf. The importance of teachers explaining the thought process used to solve mathematical problems while demonstrating how to solve problems was identified by interview participants as having a positive impact on their high school mathematics education. Teacher articulation of *how* and *why* can improve the students ability to solve the problem as well as deepen their understanding of math (Huang et al., 2005). Evelyn and Owen as well as other study participants, described how teachers providing the *thought* and the *process* used in instruction was necessary in assisting with the comprehension and conceptualization of new material. Providing time during the course of instruction for students to try problems similar to the demonstration problem, then going back over the same problem, was reported as contributing to students increased understanding of the mathematics involved-- as evidenced in the literature by Kettlewell and Henry (2009).

Study participant Alexander described the process further in his discussion about how good teachers could assess student understanding by paying attention to body language and facial expressions of students during the presentation of new material.

> Yeah if we did it he [the teacher] would look back, “You got it?” And somebody is like [Alexander demonstrates an unsure look on his face], “Are you sure you got it? I’m going to do another one just in case.” He [teacher] paid attention to us,

> everybody can say "Yeah," but, one person [shrugs shoulders] I don't know, you could tell by their face or not… They might still be struggling... But he's [the teacher] paying attention to us. If you look at people you can tell if they really get it, really understand it or not.

Paying attention to the affect of students in the classroom to determine if students understand new material is described by Alexander as an important attribute of good teaching. Participants associated their teachers who attended to body language as concerned about student learning. Kitchen, et al (2007) stressed the importance of student perception of their teacher's concern for student learning leading to increased student achievement.

Helpful caring teachers. Having mathematics teachers who are encouraging and helpful provides students with the support they needed to be successful in mathematics (Aslam & Kingdon, 2011). Ethan remarked about these types of teachers, "Instead of just lecturing, you [student] were brought into the actual learning process." In addition, participant Henry stated:

> Well it seems like I had a *mix*, there would be some that if we had an issue, they'd [teacher] go up on the board and show everybody how you did it. Some people [teachers], if you have an issue, they come to me [student] personally and they would show you. I've never had one [teacher] say "Well you'll figure it out." To the level of how much they [teachers] would solve for you [student], that would

> be one thing I saw… Some would solve more for you, and that might go back to them [teachers] knowing the kids better than I did, and may be you have to push some a little more, and let them figure it out on their own or show some a little more, let them figure it out little by little. I haven't had one [teacher] that didn't help, if we needed help. Especially like a particular problem, I know some [teachers] will get up there on the board, work the whole thing out; others [teachers] had to have two or three people have the same problem before they would work it out [on the board].

Teachers were also identified by participants as helpful if they were friendly and talked to students, not down at the students. Providing time outside of class where students could receive assistance with mathematics was also mentioned by some interviewees. Emma explained, "I had one teacher who was like I'm here after school until this time if you guys need extra help." Participant Violet explained the caring, helping attitude of some teachers:

> If we ask questions, they would answer it. After they answer the question, they would ask us if we understood, then they'd move on. If not they would continue, they would ask us where we were struggling, and what we don't understand and then they would focus in on that point. They [teachers] would try to get it across, so we understand it. And if we still don't understand it, then they would ask us to see them after class, and go over it again more one-on-one rather than in front of the whole classroom.

A teacher walking around the classroom to provide assistance to struggling students was also mentioned by interviewees as a method of providing support for learning mathematics. Hartman (1994) describes this type of instruction where they walked around assisting students as an important last step prior to students working on their own. Just as participant Owen reported about on teacher:

> She wouldn’t just sit up there and fill out lecture notes and just do problems on the board, she would walk around class and physically show you. She would write out a problem and [tell you to] solve it and then she’d walk around and people who were stuck, she’d be “All right this is what you do, this is what you’re doing wrong, this is what you’re doing right.”

Owen’s statement supports teachers approaching students, identifying who is struggling with the mathematics and providing assistance on the spot. Unfortunately, Owen’s statement also identifies the problem some mathematics teachers have staying in the front of the room and therefore not paying attention to whether students truly understand the material presented (Alper et al., 1997). Evelyn explained the process of assisting students and the importance of teachers walking around the classroom in this way:

> I think the fact that they went around the classroom asking us individually if we need help, maybe made students more likely to ask for help because kids don’t like asking in front of the whole group…people are kind of shy to ask questions in front everyone.

Evelyn’s statement supports teachers who walk around their classroom to ensure students are grasping concepts presented in class. Evelyn’s point has validity in that some students are too shy to walk up to the teacher sitting in the front of the room to ask a question. Many of the interviewees described past mathematics teachers as walking around the classroom while students were working and assisting students that needed help because, as Evelyn points out, some students are too shy to ask for help. Teachers who perused at student work around the classroom for completion and provided additional assistance to struggling students-- even if the students were not asking questions-- are supporting students in the development of new knowledge (Hartman, 1994). Grugnetti and Jaquet (2005) stress the importance of providing opportunities for students to work on problem solving while supporting the student to develop their ability to solve increasingly complex problems.

The availability of teachers to provide assistance to students in understanding the mathematical concepts and assigned problems was valued by the interviewees. Good mathematics teachers supported student learning through presenting new material by demonstrating problem solution while talking through the thought process used in the problem solution-- a concept frequently found in the literature (Alper et al., 1997; Grugnetti & Jaquet, 2005; Schmittau, 2004). Effective teachers paid attention to student facial expressions and body language, using the information obtained to provide further detail about problem solutions or to go back to a previous step in the lesson and re-explain the step using a different explanation. Participants appreciated repetition provided by teachers through using multiple examples and homework assignments to reinforce concepts taught.

Ability groups. Ability grouping, or the lack of ability grouping, was mentioned by several participants to varying degrees as having an impact on their ability to learn math without becoming bored or lost in class. Participants defined ability grouping creating classes based on student achievement in math or the creation of smaller groups within a classroom, to allow for differentiated teaching, which is supported by literature (Gregory & Chapman, 2002; Marzano, Pickering, & Pollack, 2001). Participant Sophia, who graduated from an online high school, further explained ability groups on three occasions during her interview:

> Public schools are geared to the lowest level in the class. I went to a private school until high school, so kind of bored out of my mind [after switching to public school]. And she [teacher] wouldn't help anyone that was above her lowest level…[S]ay you are doing equations with fractions and then, if you just need help on the equation, she wouldn't help you. If you needed her to explain how to do a fraction and then help with the equation, then she'd help you… Where in public schools you have [everyone] in one math class, you have the lowest levels and sometimes you have the highest level in the class. [Teachers should] gear… teaching to the different levels. Like if the lowest level is struggling with this one part, take that group of the class aside and explain it to them in a different way.

> And if the top part of the class is bored out of their minds, fiddling on their phone, give them something more challenging.

During the course of the interview, Sophia's expressed that her greatest frustration was not receiving the math assistance she needed from her teachers. The teachers' focus on the lowest level of the class resulted in additional frustrations with teacher behavior. Gregory and Chapman (2002) address multiple ability level classrooms by using flexible grouping to meet the academic needs of students. This type of instruction is often referred to differentiated instruction. Sophia's advice about separating groups of students to receive small-group instruction can be helpful to teachers who are teaching students of multiple ability levels, in that they should make sure that all group levels receive appropriate instruction.

Ethan, who also made the transition from public high school to an exclusive all boys' private high school, where he referred to teachers as professors, had the following to say about ability grouping:

> I think you [schools] just need stricter terms to get into like an honors or into certain classes. I believe the grade that you receive in the curriculum below you should definitely impact the curriculum above you, but then that requires you relying on the curriculum below you to be at par or better than the curriculum that's at the next level. It has to be something where everyone is just willing to embrace the student, and be willing to put people where they need to be not where they think they should be. So if there's a student that doesn't care [about their

> school work] but may be brilliant, they shouldn't be put in the class may be as high as they could be because they don't care about it. But if you [teachers] have somebody that tries hard and works their butt off to get a B in the class, and that's recognized they should be able to be allowed to take the class they believe fits them. But a lot of that weighs in-- especially in public school-- and the parents have so much impact on the courses their children take… kids that don't care about the stuff they get in public classes that are supposed to be harder. They [students] are in there and they don't care about it. With them [students] not caring, they get other kids in the class to not care, and then when you have basically half the class to the point where they're not paying attention and don't care, the class sort of becomes useless… The professor [teacher] can try as hard as they can but they're not going to get the class back because… It makes it so that class basically becomes void. And the ones that do care aren't going to learn as well, the ones that don't care-- don't care anyway, it just becomes a bad mix.

Alternatively, Henry, a public high school graduate, described of one of his advanced classes a bit differently, "We were all pretty much on the same level so we can move at the same pace." Henry described having students of similar ability placed together in the math class allowing the teacher to present new concepts to students in the class without having to be concerned about addressing different ability levels. As a student in the class, Henry appreciated not having to wait while the teacher repeated explanations to other students in the class. The concept of creating highly defined ability groups can contribute to persistent inequities in developing higher level mathematics skills and course taking since the groups tend to become static-- not allowing students to move between groups as needed to increase achievement (Buckley, 2010).

Teachers with multiple ability levels in the classroom, who create small groups for students to work in, also provides for opportunities for students to be able to work together as described in the literature (Gregory & Chapman, 2002; “Overcoming math anxiety,” 2007). Evelyn described one obstacle for effective group work which teachers should be aware, “Usually one person [student] carried the weight and others just goofed off.” Evelyn was reflecting on a past experience where she believed she had completed all the work in her group. Jacob provided another obstacle-- he did not like having to be social and participate in group work, but still found group work helpful. Participant Emma liked groups “… because, you guys [students] can bounce ideas off each other. You guys are still on the same page, because you all just learned it.” Emma explained that her teacher also used a variety of methods to assign students into groups, which required that students work with different groups in the classroom. Similarly, Henry’s math teacher used an alternative arrangement of the room where student desks in the room were arranged in blocks of four which supported group work. Henry described these desk groupings as creating an atmosphere supporting students working with each other, providing opportunities to share ideas on how to do assigned problems. In addition, Henry also mentioned there were occasionally off topic conversations occurring in the groups, which was acceptable to the teacher as long as the assigned work was also completed. The research supports the opportunity for students to work together in groups since this collaborative work can improve mathematics learning (Gregory & Chapman, 2002; Schmittau, 2004).

Use of Teaching Tools Including Technology

Technologies, including calculators, are often used to supplant math instruction in the classroom (Checkley, 2006). Appropriate use of technology used to support instruction increases the opportunity to solve increasingly complex problems. Technology and teaching tools can also increase instruction improving student understanding. Using a variety of teaching tools to improve the effectiveness of instruction was discussed by interview participants as having contributed to their mathematic understanding.

Manipulatives and visual aids. Small whiteboards, mentioned by both Owen and Evelyn, are used by mathematics teachers to provide the entire class an opportunity to solve problems during class time. The use of small white boards in the classroom provides the teacher the opportunity to have each student solve a problem. Subsequently, students can hold the boards up for quick review by the teacher during the class lecture (Flores & Kaylor, 2007; Kim & Axelrod, 2005). Teachers using structured, sequenced lessons can use the individual white boards to quickly determine the success level of each student in the class—providing teachers the opportunity to adjust the curriculum to meet the needs of individual students.

Participants mentioned using a variety of objects and visual aids in the math class which assisted in their learning mathematics. Owen said, “It helps you to have a physical [object] you could look at and it be tied into the lesson. It wasn’t just on paper.” Another participant, Violet, remembered her statistics teacher using various methods to elicit student responses, then, her teacher compiled the responses into data. Violet’s experiences highlight memorability of using various learning tools, however sometimes the concept taught was not as memorable. In other words, Violet remembers what they did in her math class, but not why they did it. Visual aids, along with using manipulatives, in a math classroom should be used purposefully to support math concept attainment. The concepts presented using these aids and materials need to be related to concept attainment and higher order thinking skills (Jones & Southern, 2003; Miller & Hudson, 2007; Strom, 2012; Witzel, 2005). Owen described the connection between visual aids and content when he described working with angle manipulatives which were tied directly into the lesson as helpful to his mathematical understanding. The works of Miller and Hudson (2007) as well as Witzel (2005) in special education research have identified an evidence based practice which begins with moving from concrete instruction to representational instruction and ending with abstract instruction (CRA). The use of manipulatives (concrete) and visual aids (representational) can lead to abstract learning in the CRA model. Strom (2012) advocates the use of the CRA model for all students, instead of exclusively for special education models.

Participants described other types of technology which were effectively used in the classroom. Checkley's (2006) work echoes effective classroom use of technology to supplement mathematics instruction. Participant Jacob shared the use of technology in his classes:

> She [the teacher] used a Smart Board set up with a tablet, so she would write out everything on the screen [of the tablet] and use that. That's what a lot of teachers that actually… She [a different math teacher] used an overhead camera as her main teaching tool.

Emma also explained the value of interactive instruction:

> Sometimes we had stuff where we had to do clickers, so there is up on the board a problem, some of them [teachers] would time the actual question, others [teachers would say], "So number 4 you have clicked in yet and be like do you need help or are you just not participating." That was also interactive and that helped.

Students also mentioned using computers and computer math programs on a sporadic basis in class, but unlike the use of white boards and clickers, the computers did not have an easily identifiable supportive role in mathematics instruction. Emma described the usefulness of computers outside the classroom in that they allow her to work at her own pace:

> I can't remember for the life of me what it was or for what class, but it's cool because [when using a computer] you are outside your classroom setting so it's a break, and it's not stressful, but you can just work at your own pace because it's just you and the computer. You don't have to keep up or anything else unless something is due, or you have to be here [completed a section of the computer program] by a certain point.

Calculators. Calculators were used by most interview participants for different purposes during their high school mathematics career. One participant had a teacher who used calculators connected to a hub. The hub allowed the teacher to be at the computer and see the screens of the calculators in the classroom. The use of calculators to teach mathematics has caused a debate as to whether if students are learning how to punch buttons on the calculator or learning underlying concepts and using the calculator to assist in creating that understanding (Cracolice, Deming & Ehlert, 2008; Kettlewell & Henry, 2009). Participant Sophia expressed:

> In public schools, you are required to use a calculator. Up until I got to public high school I never used a calculator, besides just a basic add, subtract & multiply [calculator]. We were never allowed to use calculators in elementary or middle school at a private school; because we had to learn how to do it [mathematics] with a pen and paper… I could do it on a pen and paper, but she [public school teacher] was showing us how to punch the numbers in a calculator, which wasn't

> teaching us to do the problem… In public school we were forced to use a calculator, if we didn't have a calculator we were screwed.

Alternatively, Jacob shared "It [math problem] was actually pencil and paper… She [teacher] taught us to do it with pencil and paper, and double check your work with a graphing calculator." Research on the use of calculators, states mathematics should be learned using pencil and paper prior to calculator use in the classroom; concepts can then be extended to create deeper understanding of mathematics by using calculators to assist in the solving of complex problems (Cracolice, Deming, & Ehlert, 2008; Kettlewell & Henry, 2009).

PowerPoint. Interestingly, participants in the study who brought up the use of PowerPoint in mathematics classrooms expressed parallel beliefs of not wanting teachers to use PowerPoint for instruction. Ethan's description of using PowerPoint in the classroom was reflective of other participants:

> Most of them [teachers]… Work through the problems up on the board, it's not like it's a PowerPoint…and that PowerPoint just sort of shows up… And I think that it so much easier to learn [with "chalk talk"], than if you have all these equations and show the logical progressions on a PowerPoint. I think that it's harder to bring that [understanding the process] in, than if you're writing down notes, watching the professor [teacher] do it [the math problem]. Watching his [teacher's] thought process as you [student] do it makes it easier to apply that

> thought process to other problems…Because the PowerPoint… doesn't give you a good enough example of how to progress from one point to the other.

PowerPoint, according to participants, provided no instructional benefit in the mathematics classroom. The use of technology and other teaching tools from an autonomy-based motivation, to support student learning within the mathematics classroom appears to have worked for participants in the study. Teachers who appeared to use technology, just to use technology, were not viewed by participants as supportive of student learning. Students want to understand both the *how* and *why* of the mathematics behind the technology as found in the literature (Checkley, 2006; Kettlewell & Henry, 2009).

Impediments to Learning

Participants in this study discussed impediments to their learning of mathematics. The impediments included:

- teachers not knowing the subject matter they were teaching
- teachers not responding with additional assistance when requested by students
- issues with classroom control and discipline
- other impediments to learning

Alternatively, the high school teachers were not entirely blamed by the participants in this study. Interestingly several participants during the interview process discussed ways in which *they* had contributed to causing discipline issues in a classroom or other steps the participant could have taken to improve their own mathematics education.

The impediments to learning were identified by many of the participants as causing frustration. Wolfe (2001) discusses the relationship between emotion and attention. The brain is programmed to pay attention to emotionally charge events, which could cause the student to focus attention on what is occurring in the classroom rather than on the lesson the teacher is presenting. When a student becomes frustrated with not understanding the material the teacher presents, it creates a bad “out of the box experience” and students may quit trying out of frustration (Kitchen, et al., 2007, p. xi). The frustration becomes greaterer if the teacher in the classroom is not immediately available to answer questions over the work.

The result of many of these barriers was participants believing they needed to teach themselves mathematics. As Alexander said, “He [teacher] was just so difficult, when he was teaching it [mathematics], everybody was like what is he talking about? And we would have to get together afterwards to try and learn it.” When Ethan was talking about his public high school experience, he shared:

> Most the time if I didn’t know anything, I just sort of taught myself…I really didn’t enjoy going to class, because I felt the class was really boring… It took a lot longer for them [other students] to learn the stuff, than it did for me.

Lack of teacher knowledge. Lack of teacher knowledge or understanding how to teach a particular subject the teacher was assigned was mentioned by study participants as contributing to making high school mathematics more difficult than it needed to be. Owen said:

> It was the way he [the teacher] taught it, you might as well been speaking Russian… I think he was so new that he didn't know, didn't have any experience to know how to teach it [mathematics]… In all honesty, I think that was because he was fresh out of college and he had to use those terms, I guess in his classes. And he hasn't switched over from going from a college mathematics degree and a high school education degree to actually teaching high school students.

Sophia put her concerns bluntly, "She [the teacher] knew absolutely nothing. I mean she had her degree and everything, but she knew absolutely nothing about geometry. She knew everything about calculus. But nothing about class she was teaching." Interviewees discussed the importance of having teachers who know the subject they are teaching, along with how to teach the subject in an understandable manner to the students in the mathematics classroom.

Teachers not responding with additional assistance. Participants reported that another barrier to their learning math was teachers who explain material once, then refuse to provide further instruction to students. If students request assistance, teachers inform students to go figure it out by themselves. Jacob explained "by quickly going through everything, and not using any examples or anything, it kind of distanced everyone. It seemed like he [teacher] expected you to know it, because he knew it." Alexander contributed the following statement about one of his teachers:

> He didn't ask us if we understood it. He just figured that we understood it because he just did [problem]… he'd [teacher] probably do it once or twice, and then he'd have us do it. And we would be like "We don't even know what you just did." We'd be like "We saw what he was doing, but I don't know, he didn't tell us how"… He didn't [explain the steps] he would just do it…And he would get mad if we didn't understand it like right when he did it. He was just like one of those smart people that if they got it, everybody should get it, when it's not like that.

Fear of the teacher or fear of math was also identified as barriers to learning by participants in this study. Alsam and Kingdon (2011), Kitchen, et al. (2007) and Smith (2002) mention a lack of fear of mathematics (math anxiety) as a prerequisite to learning mathematics. Owen briefly describes the cause-and-effect of math anxiety, "I just can't learn it. I just don't want to learn it, therefore you [himself] can't. You [students] can't learn something if you don't want to learn, and he [teacher] made it to the point that you didn't want to learn it." Sophia also admitted fear by saying:

> Every high school math teacher I had was mean…And just had that you [students] couldn't talk to them [teacher]… If your students have a question, don't make them [students] [fear] they are coming to you. I was scared of my geometry teacher.

When asked why Sophia was afraid of her geometry teacher, she continued:

> She just had that attitude and personality that you just couldn't talk to her. Like you dreaded asking her a question. I don't know if it was just the way she taught or because she fussed at us [students] if we had a question, but she scared me. I had to be careful with questions I asked her because I thought she might bite my head off.

Participants in this study identified a common need for teachers to be responsive to questions as well as provide time for questions to be asked and answered within the class period, just as Kitchen (2007) and Smith (2002) support. The frustration expressed by participants with mathematics teachers going through their explanation for a concept only once, then sending the student's home to do the work was mentioned in one form or another by *all* participants as an impediment to their learning. Many of the participants developed alternative coping strategies demonstrating their motivation to learn mathematics.

Classroom control. Classroom control, or the lack thereof, was mentioned by participants as a distraction from learning mathematics. Evelyn described the distractions as "People just be goofing off in class and I couldn't concentrate... If there were no distractions in there, I guarantee you I could've gotten A's in math. People being mean and rude was a distraction."

Ethan said of one of his public school teachers:

> My geometry teacher didn't have a very firm grasp of the class. The class started, did pretty much whatever they [students] wanted. So it was like she would talk, and at any time probably only half the class was listening and the other half were doing other things. It was sort of just a situation that was not very conducive for learning.

Poor classroom control was mentioned by interview participants as interfering with their ability to learn the mathematics taught. Research supports good classroom control and discipline as an important component in creating a learning environment supportive of student learning (Hocweber, Hosenfeld, & Klieme, 2013).

Additional impediments. Participants mentioned additional impediments to their learning. Interviewees believed that these barriers were inappropriate regardless of the subject matter taught. For example, one teacher gave bonus points at the end of the school year for bringing in supplies, such as Cora explained:

> I had one teacher that would give bonus points for bringing them batteries. So, pretty much it was like you could buy your grade. So that just kind of made me feel like the kids that were working really hard, all that year, you'd worked for nothing when you could've gotten an A [in the class] at the end for buying batteries. I'd just kind of felt it wasn't important to learn, or that the teacher thought that it wasn't [important to learn].

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Jacob discussed a teacher rushing through the curriculum of the class to discuss sports they were coaching:

> He [teacher] was the school soccer coach and somehow that style pushed its way into his teaching of mathematics which he [teacher] blew through a lot of the material very quickly, and didn't leave time for students to catch up to it [following along in the lecture]…[the teacher would say] "Here's the basics of it [the new math material], I'm not going to elaborate on it much and here's a worksheet."

Other areas where teachers created impediments to learning were teachers who made inappropriate or critical statements of the student involvement in particular clubs or extra activities. Owen was very involved in Future Farmers of America (FFA). FFA was an important club in Owen's high school, winning many competitions and awards. Owen describes:

> The math teacher was kind of facetious, a bit of a smart ass, pardon my language… He is a bit of a smart ass and he made a lot of students mad including myself. Because at that time, my big thing in high school was FFA, Future Farmers of America… And you know he'd kind of make a few smart comments like its stupid and all that. And he just put a real bad taste in my mouth about him to begin with.

Sophia spoke about a teacher sleeping or watching TV during class time, working on grading or lesson plans and instead of helping students. Henry described teachers with low expectations for student achievement if the students came from a low socioeconomic background.

At the end of his interview, Owen expressed the effect one bad teacher can have on a student:

> But just to sum everything up, I do think that one bad teacher can ruin, ruin you. It can. And indirectly, he [bad teacher] has cost me money, because I have to take remedial classes. [It has] cost me time. [It] held me up in my degree, and probably added another extra year on college, because I didn't know how to do algebra. It is true because I'm probably going to be a four and a half [year] student because I was going to pick up a minor as well. But now with being held up, I am going to be taking a victory lap, I'm going to be a fifth-year senior… But I [am not going to] get out of here in four years, so say a year's worth of tuition, classes, books, all that; a year's worth of gas, apartment, rent for apartment, taking another year to look for a job…

Owen's comments demonstrate the participants' economic costs on life and educational opportunities after high school because of mathematics teachers who impeded student learning.

Conclusion

Participants' perceptions of their high school mathematics experience highlighted the importance of listening to the student voice. This study supports what most educators currently know about learning mathematics. That is, teachers who accompanied problem demonstrations with explanations of *how* and *why* mathematics worked-- along with providing time for the participants to work in class—and were identified by the participants as being good teachers. Paying attention to the participants' understandings of concepts presented was also identified as important. Technology and other learning aides were perceived by participants as both effective and non-effective, contingent on the teachers' use of technology and other tools in the instructional process. Interview participants recalled impediments to learning, including lack of class control and teachers inability to effectively teach mathematics.

CHAPTER V

DISCUSSION AND IMPLICATIONS

Introduction

One year of a student struggling to learn math can affect the motivation of the student to continue to learn mathematics (Smith, 2002). American College Testing (ACT) reports the national average ACT math score was 20.9 in 2009 and rose one-tenth of a point to 21.0 in 2013 High school mathematics achievement has remained stagnant. Mathematics requirements for high school graduation have risen over time through the adoption of the Common Core Standards (Common Core Standards Initiative, 2014). Academic standards have increased for mathematics; however mathematics achievement as shown in standardized test scores has not significantly increased. Student voice has been used in this study to explore student perceptions of teacher instructional behaviors and actions that have impacted the students' high school mathematics achievement. Student descriptions help us to understand underlying causes for mathematics underachievement since student voice is underrepresented in the literature regarding mathematics education.

In this study, the interview process yielded rich insights into student perceptions of high school mathematics classrooms. While the interviewees had a variety of backgrounds and schooling experiences, the descriptions provided about mathematics instruction that most benefits student learning in high schools was consistent. The process of teaching and learning proposed by the participants in this study is not *formulaic*, nor is it c*onceptual* (Lewis, 2005; Mervis, 2006, Schoenfeld, 2004). The type of instruction identified as effective in promoting learning high school mathematics for students includes a combination of both formulaic and conceptual, and at best illuminating. The term illuminating could best be described as the process of teaching and learning by providing information to students on the *how* and the *why* of mathematics instruction to solve mathematical problems and explanations of the concepts in thinking processes involved. Subsequently, opportunities should be provided for students to explore similar problems with the teacher present to provide guidance and coaching.

Findings from the study participants' perceptions of teacher instructional behaviors and actions that supported or impeded their mathematics achievement are presently supported in the literature (Alper, et al., 1997; Checkley, 2006; Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; Miller & Mercer; 1997; Smith, 2002). However, mathematics instruction has not significantly changed during the last several decades. in the literature which informs us about what works to improve mathematics teaching and learning. One can only wonder why this misalignment between the current instruction and mathematics instruction literature has not significantly improved.

From the study participants' descriptions, we know that there are multiple factors in the student learning process that enabled them to interact with mathematics. For example, students appreciate teachers who take the time to explain mathematics and use a step-by-step approach to their teaching. Problem solving methods and explanation of mathematics vocabulary are believed by students to increase their comprehension and ability in applying those methods and terms to solving problems. The increased understanding of newly introduced math vocabulary allows teachers the ability to use this vocabulary when teaching additional new material and subsequently presenting further mathematics vocabulary as the class progresses to increasingly complex concepts (Fisher & Blachowicz, 2013). By providing time to work on and complete mathematics within the classroom, then having teachers go back over those problems for clarification to ensure students actually do the work correctly, is the teaching practice that *best* provided mathematical learning opportunities for student. Many times during the interview process, participants reported that those teachers who took the time to check for student understanding were viewed as caring and concerned about their progress within the educational framework. Teachers who taught without paying attention to students' body language and/or student facial expressions were also not viewed as caring or concerned about their progress. As a matter of record, the participants viewed this type of teacher as unresponsive to their questions. Many of those interviewed reported believing that they were forced to teach themselves mathematics-- through the use of the internet, textbooks or friends—to be successful within the class.

Smith (2002) and Alper, Fendel, and Fraser (1997) identified four essential conditions for learning mathematics:

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- Curriculum needs to be understandable and interesting.
- Personal validation of progress without anxiety.
- Active engagement and student belief math can be done.
- Time and reason for students to learn provided.

Interview transcript analysis found three overarching themes:

- Providing ongoing support of student learning.
- Use of teaching tools including technology.
- Impediments to learning.

Study analytical themes derived from participant descriptions which are most helpful, support the four essential conditions of learning as listed above. The study analytical theme of providing ongoing support of student learning highlights the essential conditions of time to learn, personal validation of progress and making curriculum understandable. The analytical theme of using teaching tools including technology supported the essential conditions of making curriculum understandable and interesting along with active student engagement in the learning process; as long as the teaching tools and technology were used to supplement, not supplant, the mathematics taught. The last analytical theme-- impediments to learning-- provides insight into mathematics teachers' behavior during the instructional process to negate the presence of the four essential conditions identified as increasing student learning of mathematics.

Support of Student Learning

Students need for both formulaic and conceptual understanding to be supported within the mathematics classroom. The ongoing debate between a formalistic and conceptual approach to teaching mathematics was described by Schoenfeld (2004). Schoenfeld advocates an instructional approach, including both the formalistic and conceptual approaches to improve both mathematics instruction and student achievement. Lewis (2005) and Mervis (2006) support Scheonfeld's approach using both formulaic and conceptual teaching and learning in mathematics. The need for a process to follow in order to solve problems acts as a starting point in the student's ability to complete assigned mathematics. A combination of formulaic and conceptual understandings allows students an opportunity to internalize mathematics concepts. This internalization can be supported when teachers allow students to use a non-standardized approach to solving mathematics problems through conceptual understanding.

Varied approaches and instructional practices were valued by students. When students request that teachers further explain how to do problems, students place a high value on teachers who use alternative explanations or methods to elaborate on problem solutions. When students are confused with new instruction, and ask a question, then subsequently teachers repeat the exact same explanation, students became frustrated. Students also became frustrated when other students ask *repeated* questions about the same concept students may have understood the first time it was presented by the teacher.

Kitchen, et al. (2007) found student frustration levels increase when they do not understand mathematics, contributing to students' failure to learn mathematics.

Interestingly, the solution proposed to decrease frustration levels of participants who struggle with mathematics-- and those who perceive themselves as good at mathematics-- was to use more ability grouping within the mathematics classes. Flexible ability grouping used within classrooms to improve student achievement is supported throughout literature (Gregory & Chapman, 2002; Marzano, Pickering, & Pollack, 2001).

Helpful caring teachers. Successful students in mathematics have mathematics teachers who are encouraging and helpful (Aslam & Kingdon, 2011). Actively involving students in the learning process is identified as important to developing conceptual understanding of mathematics in a 1989 report, *Everybody Counts* published by the National Research Council on the future of mathematics education. Using a problem solving base along with active engagement of students in mathematics education continues to be a reoccurring theme to improve mathematics achievement (Grugnetti & Jaquet, 2005; Martin & Bassock, 2005).

Students describe helpful caring teachers as making the student part of the learning process. Students describe their ability to gain assistance from teachers when solving mathematics problems as necessary to improve their understanding of the concepts presented. Teachers who walk around the classrooms to support students struggling with problem solution and who provide assistance are believed to be good teachers by students. In addition, teachers who move about the classroom to assist students are viewed by students as having the ability to better address their concerns and questions, even when students were too shy to ask questions during class time. Effective teachers should pay attention to student facial expressions and body language to assist the teacher in determining each student's comprehension of the material presented in class.

The literature on mathematics education is parallel with findings in this study. Teachers should be aware of their students' perception of the teachers' concern for student learning. Student perception of teacher concern leads to increased student achievement in mathematics (Kitchen et al., 2007).

Ability groups. Differentiated teaching uses flexible groupings within a classroom to support different achievement levels of students (Gregory & Chapman, 2002; Marzano, Pickering, & Pollack, 2001). The differing achievement levels present in mathematics classes is problematic for students. Teachers are viewed as designing instruction to meet the needs of the lowest achieving students in class. Teaching to the lowest levels of the class causes students to be frustrated with their teachers and bored with the class. The use of flexible groupings within a classroom can alleviate some of the frustration and boredom experienced by students (Gregory & Chapman, 2002; Marzano, Pickering, & Pollack, 2001). The phrase "out of the box experience" (Kitchen et al., 2007, p. xi), commonly used to describe how technology must be consumer friendly, also applies to learning mathematics. The presentation of new concepts in mathematics must be understood by students or consequently, students will believe that mathematics is beyond their ability to comprehend. Flexible ability grouping can provide additional support to improve mathematics achievement.

Some study participant solutions to improve ability grouping within the classroom seemed very practical. One such solution is to have the teachers move those students who were struggling with the concept into smaller groups to provide further instruction, while allowing students who demonstrate understanding to begin on their homework. Small groups would be flexible and dependent on which students were struggling with the topic presented. The groups within the classroom would not be permanently assigned to students but ad hoc groups created as need for additional instruction arose. Students could participate in the additional instruction as needed for comprehension.

Another solution suggested for implementation of ability groups was suggesting that schools maintain higher entrance requirements for enrollment in honors mathematics courses-- and to enforce those requirements. Thus, high-level students could progress through math lessons quickly with increased depth of mathematics. One participant in this study attended a private school which used a three-tier approach to mathematics classes. In this approach, students were designated to be in the A, B or C group. These subject matter mathematics groupings held for the year, then, students could move between groups at the end of each year-- dependent on their academic achievement in mathematics. Students could benefit from this system in that students who are apt to be on the same level mathematically enable teachers to teach to one group instead of having to differentiate instruction to meet the needs of several different groups within the classroom-- just as explained in Gregory and Chapman (2002).

The use of highly defined, static ability groups does not allow for students to move between groups as needed to increase achievement (Buckley, 2010). High school students believe that flexible ability grouping could provide an opportunity for increasing individual mathematics achievement. Furthermore, the opportunity for students to work together provides for improved mathematics achievement (Gregory & Chapman, 2002; Schmittau, 2004). Using flexible ability groups within a classroom provides opportunities for teachers to be able to remediate within the classroom for missed concepts (Bahr, 2010).

Teaching Tools and Technology

Student reactions to using technology within the classroom are varied. Students believe the use of PowerPoint to explain mathematical problems or concepts are not helpful because it is too difficult to follow the steps for problem solutions. One of the study participants referred to another type of teaching as “chalk talk” where teachers write problems on the board while explaining the though process. Teachers who use chalk talk are viewed as having a positive effect on a student’s belief about their ability to understand and achieve mathematically. Some study participants provided examples of the teachers using chalk talk through using a document camera or a tablet connected to a Smart Board-- while walking around the classroom-- so that the material appeared on a Smart Board as the teacher worked out and discussed the problem demonstration.

The "out of the box experience" (Kitchen et al., 2007, p. xi) describes how technology is often returned if it does not immediately work problem-free after removal from the box. This concept can also be applied to mathematics education. Students often become frustrated with teachers who were unable or unwilling to provide instruction that they can comprehend. This frustration was specifically mentioned by study participants when discussing the use of PowerPoint in the classroom. Students become frustrated when they are unable to understand their teachers' thought processes, especially when the steps to arrive at a solution are unclear.

Manipulatives and visual aids. Concrete, representational, and abstract (CRA) is an instructional model first used in special education classrooms and subsequently found to be effective with regular education students as well (Miller & Hudson, 2007; Strom, 2012; Witzel, 2005). The instructional model has students working with concrete objects that can be manipulated to solve problems as a first step. The second step in the process is to have students work with representations of the concrete objects, rather than the object, to solve problems. The final step is to have students working abstractly, without either the concrete objects or the representations of the objects. Presenting curriculum using the CRA model provides opportunity for the student to move from the formalistic understanding to conceptual understanding of mathematics. Concepts presented using concrete objects as well as representations must be related to concept attainment and higher-order skills (Jones & Southern, 2003; Miller & Hudson, 2007; Strom, 2012; Witzel, 2005). Special education research has also supported the use of organizers, cueing, color coding, various tutoring strategies in addition to including the concrete tactile materials (Maccini & Gagon, 2006).

Students enjoy using a variety of manipulatives and visual aids in mathematics classrooms. One interviewee discussed a mathematics teacher using the answers to student questionnaires to create datasets for a statistics class; however, the mathematics concept was not remembered. Other participants remembered using tools, including angle manipulatives, which were directly tied to the concepts presented. When the use of manipulatives is directly related to concept attainment, mathematical understanding on a conceptual level can be improved (Jones & Southern, 2003; Miller & Hudson, 2007; Strom, 2012; Witzel, 2005). Kettlewell and Henry (2009) identified five interdependent strands of mathematical knowledge. The interdependent strands are:

- Conceptual understanding.
- Procedural fluency.
- Strategic competence.
- Adaptive reasoning.
- Productive discipline.

The use of manipulatives and visual aids in a mathematics classroom supports the strands listed above, especially when using the CRA model.

Technology. Students discussed the use of Smart Boards, document cameras, clickers and computers in mathematics classrooms. One participant reported a teacher using a tablet in conjunction with a Smart Board, which can provide the teacher with the opportunity to have work display on the Smart Board while walking around and writing on the tablet. Students believe this use of technology to be very helpful and provide the teacher with an opportunity to continue concept presentation while addressing individual student concerns found while walking amongst the class.

Clickers are an instructional tool used in conjunction with a whiteboard or computer to allow individual students to select a multiple-choice answer to a presented problem. Teachers can assign clickers to students using a numbering system. Since a whiteboard or computer can record each answer by number as students click in, teachers can offer assistance to the nonresponsive student. Students perceived this type of instruction as directly involving them in their math instruction.

Taylor (2006) supports instructional curricular changes in mathematics as technical knowledge increases. Computers can have an increasing impact on mathematics education with the use of web based instruction programs such as Khan Academy (2014). Khan Academy is offered free to anyone who wants to use the program, including entire school districts. As populations in high schools become increasingly diverse, teachers strive to meet the need of the changing student population (Stodolsky & Grossman, 2000). Mathematics programs based on computers in the classroom or on the web should increasingly be used to improve mathematics achievement of increasingly diverse student populations. Computer usage without a direct link to the formalistic or conceptual mathematics curriculum taught in the classroom should be omitted.

When students discuss the use of computers and computer math programs, there is no easily identifiable role in how they improve student achievement. While students enjoy working with computers, they fail to mention mathematics understanding and achievement as their purpose for enjoying electronic math instruction. Time outside the regular classroom setting and not having to progress through mathematics at the same pace as their peers in the class are the primary reasons students appreciate computer work in a mathematics classroom. Using computers to support instruction with programs directly connected to curriculum standards could assist to increase student mathematics achievement.

Calculators. The use of calculators in math classes is supported by most students when calculators are used after students have learned the mathematics concepts involved. Students do not want to *only* learn how to push the correct buttons on a calculator to solve the problems, but instead they want to know why they push particular buttons to solve problems. The implication here is that teachers should spend more time ensuring that students learn the concepts behind the mathematics while using a calculator, rather than a series of steps for which buttons are pushed to receive the correct answer from a calculator. Checkley (2006) states that technology should supplement mathematics instruction not supplant instruction. In other words students appreciate technology used in a mathematics classroom when it is used appropriately to increase their achievement. Students appreciated the use of technology which provides them with the opportunity to interact with mathematics, providing opportunities to increase conceptual understanding; punching buttons on the calculator is not viewed as a way to increase this conceptual understanding.

PowerPoint. The use of PowerPoint in the mathematics classroom was not a preferred presentation method by study participants. Students believe that PowerPoint fails to provide an opportunity to understand the *why* of the problem solution. PowerPoint presentations show concepts as a series of slides, with material written out for ease of presentation. According to students, the thought processes teachers used in solving problems are more evident if the teacher is actually writing the problem out at the same time they were talking about how to do the problem. As one participant in this study mentioned, it is as if the problem "just sort of shows up." Students prefer to see the instructor writing the material down, while providing explanations the steps used to solve the problem.

Communication of what is occurring during each step of the problem-solving process is reported by students as increasing their mathematical understanding of the problem solution. According to Schoenfeld (2004), the *how* and the *why* of mathematics should be provided to ensure that students learn the formulas of how to solve problems while developing the reasoning skills needed to move to a conceptual understanding of mathematics. Educators working to improve student achievement in mathematics should not be using PowerPoint according to students. There are other technologies to use during mathematics instruction which are more supportive of increasing their mathematics achievement.

Impediments to Learning

Students identify impediments to their learning that can block the presence of the four essential conditions for increasing the mathematics learning in the classroom—as previously identified in the literature (Alper, Fendel, & Fraser, 1997; Smith, 2002).

Lack of teacher knowledge. Teachers who are not able to effectively teach their classes, whether due to lack of knowledge of the curriculum or teaching strategies, can create frustration with students. Danesi (2207) stresses communication as an important tool in increasing mathematics achievement of students.

Students can become frustrated with a teacher's inability to effectively communicate mathematics curriculum. This failure to communicate effectively translates into the curriculum which is not understandable, along with creating student disengagement from the lesson presented. Some students who cannot understand the teacher's math instruction are motivated to either work with other students or seek out additional support to learn mathematics curriculum. Since all interviewees in this study were recruited from a university environment to share their high school mathematics experiences, this type of motivation to find alternative methods to learn mathematics-- in spite of the teacher-- may not be present in other high school students. Evidence of teacher incompetence was not provided by the study participants. Students who believe a teacher is incompetent because of the teacher's inability to present curricular materials understandably to the student reduces student achievement in mathematics (Alper, et al., 1997; Checkley, 2006; Kitchen, DePree, Celedon-Pattichis, & Brinkerhoff, 2007; Miller & Mercer; 1997; Smith, 2002).

Teachers who fail to provide additional assistance. Lack of anxiety of mathematics is essential to increased student learning of mathematics ("Overcoming math anxiety," 2007). The creation of a classroom environment supportive of learning mathematics, free from fear or anxiety, is needed for mathematics achievement. Math anxiety has been extensively studied in special education research (Kozik, Cooney, Viciguerra, Gradel, & Black, 2009; "Overcoming math anxiety," 2007). Information on how to reduce math anxiety provides strategies to use within a regular education classroom to reduce levels of anxiety for struggling students. Instructional practices found in the literature reduce math anxiety are:

- Time in class for students to work on problems.
- Use of groups of students to solve difficult or complex problems
- Providing immediate assistance

Overcoming math anxiety is critical to increase student achievement in math. Fears toward math or the mathematics teacher are barriers to learning mathematics (Alsam & Kingdon, 2011; Kitchen et al., 2007; Smith, 2002).

Students describe teachers who refuse to provide additional assistance when requested by the student as contributing to their math anxiety or fear in the classroom. Unsupportive teachers are also viewed by students as not being concerned about student learning. Teachers refusing to provide additional assistance when requested during class time should provide alternative arrangements for students to receive the support needed to achieve mathematically. The alternative arrangements could include; recommendation to stay after class or after school for additional assistance; tutoring available within the school system; or access to free web-based programs. Teachers must believe students are capable of learning and achieving in mathematics (Alper, Fendel, & Fraser, 1997; Smith, 2002; Stodolsky & Grossman, 2000). Teachers who refuse to answer student questions and insisting students go look up the questions on their own, fail to demonstrate their belief that the students are capable of learning and achieving in mathematics.

Classroom control. Lack of discipline in the classroom is identified by students as an impediment to their learning math. Students find it too difficult concentrate on the class material presented if other students were misbehaving or talking in class. Interestingly, in this study, some interview participants admitted to also misbehaving at times and becoming part of the problem in those same classes.

Research shows an important component of a supportive learning environment to improve student learning is good classroom control and discipline (Hocweber, Hosenfeld, & Klieme, 2013). Students believe that their personal mathematics achievement could be higher if there were no distractions or other students misbehaving in their math classes. Some teachers continue to present lessons to mathematics classes regardless of whether the students in the class are paying attention. Active involvement in the lesson is required for mathematics achievement (Alper et al., 1997; Smith, 2002), which does not occur in poorly disciplined classrooms.

Additional impediments to learning. Students say that there are additional barriers to their learning that can be considered inappropriate and contributing to the lack of achievement in any subject. Some teachers offer grade reciprocity such as a teacher having students bring supplies for extra credit, at the end of the school year. The message can be perceived by some students as nonperforming students offered an opportunity to buy their grades—creating resentment from those students who worked for their grade. Other teachers rush through instruction in order to discuss other topics, such as sports.

Students also say that there are teachers who impact their ability to learn by teacher actions that are cruel and meant as personal attacks and therefore struggle to be engaged in mathematics lessons. Students report that some teachers even sleep or watch TV during class, work on their grading or lesson plans for the next class, or have expectations for students based on the socioeconomic background of the student. The barriers presented by students can result because of a teacher's failure to establish a classroom environment conducive to increasing student achievement. Teachers must adapt to student diversity, socioeconomic background, and increasing technology-- to create and support classroom learning environments conducive to student learning (Stodolsky & Grossman, 2000). Supporting all students in achieving mathematically must be a goal of all mathematics teachers (Norman, 1988; Watt, Shapka, Morris, Durick, Keating, & Eccles, 2012).

Conclusion

Research into mathematics achievement in education is extensive (Hayes, 1992; Klein, 2007; Lewis, 2005; Reys & Reys, 2011; Smith, 2002; Woodward, 2004). The ongoing debate between conceptual and formulaic approaches to mathematics instruction has resulted in proscribed mathematics curriculum shifting from a concentration on either the *how* or the *why.* The descriptions revealed about math instruction that facilitated or hindered the study participants' ability to learn high school mathematics is supported by the literature. Participants' insistence on knowing both the *how* and the *why* coincides with finding a middle ground between formalistic and conceptual approaches to math education from research by Schoenfeld (2004), Lewis (2005), and Mervis (2006). Researchers of mathematics education, both from special education and regular education have been informing best practices using the same strategies and approaches identified by the participants as improving their personal mathematics understandings. One can only wonder why research-based effective instruction has not been implemented in the classroom.

Mathematics teachers at the secondary level must understand the importance of implementation of research-based practices to improve *all* students' mathematical achievement. From my past experience as a high school administrator and mathematics department chair, the teacher excuse given for not implementing research was that the research was theory, and not practical for implementation in the classroom. Participants in this study report having mathematics teachers at the secondary level who have implemented instructional strategies in the classroom which coincide with research and perceived by interviewees as improving their mathematics achievement. Since some mathematics teachers are not implementing research-based practices in their own school and district, leadership must become involved.

School and district leadership must identify practices implemented in mathematics classrooms throughout their school or district which have an impact on student achievement (Rothman, 2009). Instructional practices and teacher behaviors found in this study which create impediments for student achievement must be eliminated from the school or district. Instructional practices which positively impact student achievement must be recognized and expanded throughout the school or district. In a time of high stakes testing—ACT score have improved by one-tenth of a point since 2009 (ACT, 2014)-- and the number of high schools struggling to significantly increase student mathematics achievement scores, identification of teaching and learning methods which have positive impact on student mathematics learning would provide insight on how to better support teachers and teachers' work to increase student achievement.

School administrators who supervise evaluation of mathematics teachers must be trained to recognize good methodology for teaching mathematics to increase administrators' expertise in evaluating mathematics teachers—especially when they lack subject matter knowledge—before math instruction can progress. School administrators who are unsure of subject matter content must be provided with tools, and recognize effective instruction in a particular subject. Administrators may evaluate mathematics classrooms based on appropriate teaching strategies from their own past subject matter expertise. Teaching strategies from other secondary school subjects may or may not be appropriate to teaching mathematics. The failure to effectively evaluate mathematics teacher contributes to the status quo—failure to improve mathematics achievement.

Limitations

Since all participants in this study are enrolled in a university, requirements for university enrollment have been met. The findings of this study may not be applicable beyond the study participants, and may not inform practices to improve mathematical achievement for *all* students. This study provides a foundation for further research into how teacher behaviors and actions can influence mathematics achievement for students at the secondary level.

The participants in this study were previously students from public, private, and online high schools, along with one participant who received a general education diploma (GED). The descriptions of those contributions in creating an effective high school mathematics classroom were similar for all interview participants. While the processes identified as contributing to student learning are common among the study participants, the processes may not apply to all students in high school mathematics. Perceptions of the participants are based on memories of recent high school experience and may not reflect the same impediments and supports to learning of mathematics as others who are older and more distanced from their high school years.

Further Research

Further research is necessary to determining if illumination, which is teaching between the formulistic and conceptual approaches, provides the best support for student learning for those who do not matriculate to a university. Students who attend trade, technical or community college after completing high school may have contradictory perceptions about their high school mathematics experience than those expressed in this study. The perception of the high school mathematics experience may also be different for students entering the workforce or military after high school. An investigation of student perception of various groups should be completed to determine if illumination provides the best support for increasing mathematics achievement.

Future research in mathematics education should continue to involve student perceptions of successful mathematics teaching. An additional source of information which could impact the identification of promising mathematical practices is classroom observations. During classroom observations, mathematics teachers are usually on their best behavior. The problem is determining if the observed behavior is the teachers' typical behavior in class. Information gained from interviews with students, along with administrative walk-throughs (short 5 to 10 minute visit to classrooms on a regular basis looking for evidence of good instructional practice,) could assist in assessing the validity of the classroom observation is representational of the teachers' instructional practice and behaviors. Teacher instructional practice and behaviors have a direct impact on student achievement.

Further research could include how teacher behaviors and actions influence mathematics achievement and should involve all stakeholders in the high school educational experience. Parents, students, high school administrators, district office administrators, teachers and community members may all have varying perceptions as to effective mathematics teaching within the high school. In addition, observations of that which is actually occurring within the high school mathematics classroom should be examined in conjunction with student interviews to assist in further identification of promising classroom practices to improve mathematics achievement for all students.

Concluding Discussion

Over the past three decades, mathematics achievement has not significantly improved. Literature on mathematics education exists, highlighting what has worked to improve mathematics education. Participants in this study concur with the literature on necessary changes in classrooms to improve mathematics education. Since literature has shown effective instruction that parallels the participants in this study, further investigation should be conducted to determine why all teachers have not implemented effective instruction to improve mathematics education.

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APPENDIX A

Classroom Questionnaire Protocol

Student Voices on High School Math

Classroom Questionnaire Protocol

My name is Elizabeth Crane. Thank you for participating in this study. The purpose of the study is to explore high school math teacher behaviors and how the behaviors impacted your ability to learn math in high school. Your name and any other identifying information will be kept confidential. My interest in the subject has developed over the last 25 years or so of teaching math and evaluating math teachers. I am interested in the student perspective of high school math. I would like the opportunity to discuss with you your experiences in high school math to examine the teacher behaviors that impacted you and how they impacted you. If you are willing to be interviewed, please provide your name and contact information for scheduling of a possible 1 hour interview. The information collected will be used for possible future publication as well as to complete my dissertation. If at any time you have a question let me know.

To start off, I would like to collect a little background information. Again, let me stress all information is confidential. **Completion of the survey is voluntary.** (Hand out the short questionnaire) I would appreciate you answering the following demographic questions.

(Wait time to fill out the questionnaire, and then collect it.)

APPENDIX B

Classroom Survey

Student Voices on High School Math

Thank you for taking the time to complete this survey. The survey should take about 10 minutes to complete. Please answer the question honestly. The survey is to collect demographic data for possible inclusion in a study on high school mathematics. Your identities will be kept confidential. Please include your name and contact information if I may contact you for participation in an interview on your high school mathematics experience. The information you shared could be part of future publications on math education as well as being published as part of a dissertation on student perspectives of high school mathematics. All names and contact information provided will be removed and replaced with random numbers or pseudonyms.

Please fill in the blanks or circle the appropriate answer

1. What high school did you graduate from?

   ____

2. What year was that?

   2011 2012 2013 did not graduate other

3. How did your high school score on the state standardized tests?

   High Average Low

4. What math classes did you take in high school? Circle all that apply.

   Pre-Algebra Algebra I Geometry Algebra II

   Pre-Calculus Trigonometry AP Calculus AB AP Calculus BC

   AP Statistics Other:___________________________________

5. What was your overall GPA in high school?

   0 – 1.0 1.0-2.0 2.0-3.0 3.0-4.0 4.0 or higher

6. What was your average grade for your mathematics classes in high school?

   A B C D F

7. What was the first math course you took at the university?

   ____

8. What semester and year did you take your first math class? ________________

9. What was your grade?

   A B C D F

10. What is your ethnicity? ____

11. What is your Major?____

12. Are you willing to be interviewed on your perceptions of high school mathematics?

    If so please provide your name and contact information below:

    Name:____

    Contact

    phone:____

    Email address:____

APPENDIX C

Interview Protocol

Student Voices on High School Math

Interview Protocol

My name is Elizabeth Crane. Thank you for participating in this study. The purpose of the study is to explore high school math teacher behaviors and how the behaviors impacted your ability to learn math in high school. Your name and any other identifying information will be kept confidential. My interest in the subject has developed over the last 25 years or so of teaching math and evaluating math teachers. I am interested in the student perspective of high school math. I would like the opportunity to discuss with you your experiences in high school math to examine the teacher behaviors that impacted you and how they impacted you. The information collected will be used for possible future publication as well as to complete my dissertation. If at any time you have a question let me know.

Here is a consent form which needs to be signed. The interview will be recorded for future transcription and analysis.

Interview Questions

Main question:

- Tell me about your math experience in high school.
    - What made the experience good, were there years it went better than others and why?

- What has had the biggest impact on learning math for you personally, and why?

Follow up questions:

13. Tell me more about what the teacher did in class that made it better or worse for you to learn mathematics?
14. What happened if you did not understand your math homework?
    a. What happened if you did not understand the math classwork?
15. What did the math teacher do if you or others in class were not working?
    a. How did the teacher's actions impact you?
16. What types of choices were you given about activities in math class?
    a. How did the teacher's behavior impact your choices?
17. During your math class, did the teacher provide time to work on your math assignment?
    a. What was the teacher's response if you asked the teacher a question?
        i. What was the teacher's response if someone else asked the teacher a question?
        ii. If the teacher responded differently, what were the differences?
    b. What were the teacher's actions and behaviors during seatwork time?
18. How did your teacher's behaviors and actions influence your belief about your ability to do mathematics?

19. How did the math teacher structure class time on a typical day?
    a. Was the class structure ever varied from the typical day?
    b. Why do you think the teacher altered the structure?
    c. How did that impact your ability to learn math?
    d. How do you think that impacted other student's ability to learn math?
20. How did the teacher present new topics in math?
    a. What did the teacher do that made you feel you could master the material?
21. What did the teacher do if you asked a question or did not ask questions?
22. Were there activities outside of your math class that impacted your ability to learn math?
    a. What were they and how did they impact you?
23. What made the difference between the best and worst math teachers that you had in high school?
    a. How did they make you feel about math and your ability to do math?
24. Is there anything else you would like tell me about your high school math experience we have not already discussed?

APPENDIX D

Informed Consent

Consent to Participate in a Research Study

Student Perceptions of Their High School Mathematics Experience

Why am I being asked to participate in this research?

You are being invited to take part in a research study about high school mathematics. You are being invited to participate in this research study because you have recently graduated from high school, within the last 3 years. If you take part in the interview portion of this study, you will be one of about 15 people to do so.

Who is doing the study?

The person in charge of this study is Elizabeth Crane at EKU. She is being guided in this research by Dr. Erickson and Dr. West. There may be other people on the research team assisting at different times during the study.

What is the purpose of the study?

I am conducting qualitative study on the high school math experience from the student's perspective. You are invited to participate. The purpose of this study is to explore student perceptions of their high school mathematics experiences. I hope to discover what teacher actions and behaviors have had an effect on your high school math experience.

Where is the study going to take place and how long will it last?

The research procedures will be conducted at EKU. If you volunteered for an interview, and were selected to be interviewed, you will need to come to a mutually agreed location at EKU one time during the study for an interview lasting one hour with a possible request at a later date to provide clarification to information in the transcript.

What will I be asked to do?

You will be asked to participate in an interview about your high school math experience.

Are there reasons why I should not take part in this study?

You must have graduated high school in the last three years and be over the age of 18.

What are the possible risks and discomforts?

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

You may, however, experience a previously unknown risk or side effect.

Will I benefit from taking part in this study?
There is no guarantee that you will get any benefit from taking part in this study. We cannot and do not guarantee that you will receive any benefits from this study.

Do I have to take part in this study?
If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

If I don't take part in this study, are there other choices?
If you do not want to be in the study, there are no other choices except to not take part in the study.

What will it cost me to participate?
There are no costs associated with taking part in this study.

Will I receive any payment or rewards for taking part in the study?
You will not receive any payment or reward for taking part in this study.

Who will see the information I give?
Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. You will not be identified in these written materials.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, your name will be kept separate from the information you give, and these two things will be stored in different places under lock and key.

However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information that identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as Eastern Kentucky University.

Can my taking part in the study end early?
If you decide to take part in the study, you still have the right to decide at any time that you no longer want to participate. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to end your participation in the study. They may do this if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you.

What if I have questions?
Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, Elizabeth Crane at 502-682-5646. If you have any questions about your rights as a research volunteer, contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636. We will give you a copy of this consent form to take with you.

What else do I need to know?
You will be told if any new information is learned which may affect your condition or influence your willingness to continue taking part in this study.

I have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and agree to participate in this research project.

____
Signature of person agreeing to take part in the study Date

____
Printed name of person taking part in the study

____
Name of person providing information to subject

APPENDIX E

Supporting Tables for Chapter 3

Student Voices on High School Math

Percentages in table are out of the 105 survey participants who included both high school math courses and first colligate math course enrolled in. Only the highest levels of high school math reported by the survey participants are included in tables E.1 and E.2.

Table E.1

United States and Middle East participants' initial college math course

		Starting colligate course (%)									
HSC	NP	Remedial			College level						
		PA	I	II	App	AF	CA	Trig	Calc 1	Calc 2	MT
BM	1	.95									
PA	3	.95			1.90						
I	7	5.71		.95							
Geo	20	6.67	2.86	1.90	3.81		2.86	.95			
II	33	11.29	6.67	2.86	7.62		2.86				
PC/Trig	25	4.76	4.76	1.90	2.86	.95	4.76	1.90	.95		.95
AP Calc	9	.95		1.9	.95		.95		.95	.95	1.90
Stat	2		.95					.95			
Adv	5		2.86		.95		.95				

Abbreviations: High school classes – HSC Number of participants – NP

High School Mathematics	**College Mathematics**
Pre-algebra – PA	Pre-algebra – PA
Basic math – BM	Introductory algebra – I
Algebra I – I	Algebra II – II
Geometry – Geo	Math with applications - App
Algebra II – II	Applied finite math - AF
Pre-Calculus – PC	College algebra - CA

Table E.1 (continued)

Trigonometry – Trig	Trigonometry - Trig
AP Calculus – AP Calc	Calculus 1 – Calc 1
AP Statistics – Stat	Calculus 2 – Calc 2
Other advanced math - Adv	Math for teachers – MT

Percentages in table are out of the 92 survey participants who attended high school in the United States and included both high school math courses and first colligate math course enrolled in. Only the highest levels of high school math reported by the survey participants are included in tables E.1 and E.2.

Table E.2

United States participants' initial college math course

		Starting colligate course (%)									
HSC	NP	Remedial			College level						
		PA	I	II	App	AF	CA	Trig	Calc 1	Calc 2	MT
BM	1	1.09									
PA	1				1.09						
I	3	2.17		1.09							
Geo	20	7.61	3.26	2.17	4.35		3.26	1.09			
II	31	11.96	6.52	3.26	8.70		3.26				
PC/ Trig	22	4.35	4.35	2.17	3.26	1.09	4.35	2.17	1.09		1.09
AP Calc	7	1.09			1.09		1.09		1.09	1.09	2.17
Stat	2		1.09					1.09			
Adv	5		3.26		1.09		1.09				

Abbreviations: High school classes – HSC Number of participants – NP

High School Mathematics	**College Mathematics**
Pre-algebra – PA	Pre-algebra – PA
Basic math – BM	Introductory algebra – I
Algebra I – I	Algebra II – II
Geometry – Geo	Math with applications - App
Algebra II – II	Applied finite math - AF
Pre-Calculus – PC	College algebra - CA

Table E.2 (continued)

	Trigonometry – Trig	Trigonometry – Trig
	AP Calculus – AP Calc	Calculus 1 – Calc 1
	AP Statistics – Stat	Calculus 2 – Calc 2
	Other advanced math - Adv	Math for teachers – MT

Appendix F

Summary of findings

Table F.1

Summary of findings

Heading	Teaching Behaviors Identified by Participants				
Support of Student Learning	Vocabulary explained in common language working towards math terms	Explain the how and the why of the problem during demonstrations (Chalk talk)	Paying attention to facial expressions and body language		
Helpful Caring Teachers	Brought student into learning process	Talk to, not down to students	Provide assistance during and outside of class	Teacher walking around the room	Provide additional detail if needed
Ability Grouping – Based on Student Math Achievement	Differentiated learning	Flexible groupings	Strict entrance requirements for honors	Instruction directed at one level instead of multiple levels	Group work provided
Teaching Tools and Technology					
Manipulatives and Visual Aids	Small individual whiteboards	Physical objects tied to the lesson	Student responses to create data for analysis	Smart Board with tablet	Clickers
Calculators	Teach how to do math first	Do not just teach which buttons to push	Create deeper understanding with calculators after concepts are understood by students		
PowerPoint (PP)	Do not use PP to explain problem				
Impediments to Learning	Teaching not knowing or able to communicate subject matter taught	Not responding positively to requests for additional assistance	Lack of classroom control and classroom discipline	Bonus points effecting grade for classroom supplies	Teacher sleeping or watching TV in class

Appendix G

Comparison of regular math education research with special education research

Table G.1

Comparison of regular math education research with special education research

Topic	Regular Education Research	Special Education Research
Response to Intervention	Lembke, E. S., Hampton, D., & Beyers, S. J. (2012)	Allsopp, Kyger, Lovin, Gerretson, Carson, & Ray, (Feb2008)
Support to Teach Between Formalistic and Conceptual Approaches	Davidson, D. M., & Mitchell, J. E. (2008); Klein, D. (2007); Lewis, A. C., (2005); Mervis, J., (2006); Schmittau, J. (2004); Schoenfeld, A. H. (2004)	Cole, J.E., & Wasburn-Moses, L. H. (2010
Integrated to Support Direct Instruction for all Students	Flores, M. M. & Kaylor, M., (2007)	Flores, M. M. & Kaylor, M., (2007)
Direct Instruction	Kim, T., & Axelrod, S. (2005);	Jones, E. D., & Southern, W. (2003)
Differences in Instructional Practices Between Regular Education and Special Education Teachers	Maccini, P., & Gagon, J. C. (Winter 2006)	Maccini, P., & Gagon, J. C. (Winter 2006)
Concrete, Representational, Abstract (CRA)	Strom, E. (2012); Witzel, B. S., (2005)	Miller, S. P., & Hudson, P. J. (2007) ; Witzel, B. S., (2005)
History of Mathematics	Reys, R., & Reys, B. (2011)	Woodward, J. (2004)

VITA

Elizabeth A. Crane

Education

Doctorate in Educational Leadership and Policy Studies, awarded 05/2014. Eastern Kentucky University, Richmond, KY

Graduate work in Educational Policy – 1999-2004 - University of California, Riverside, CA

Clear Professional Administrative Services Credential – 1998-1999 – California State University, San Bernardino, CA

Masters in Educational Administration – 1990 - California State University, San Bernardino, CA

Teaching Credential – 1982-1985 – California State University, San Bernardino, CA

Bachelors in Business Economics – 1983- University of California, Santa Barbara, CA

Associates in Economics – 1978 - Chaffey Community College, Rancho Cucamonga, CA

Credentials

Kentucky

Professional Certificate for Director of Pupil Personnel, Level 2

Professional Certificate for Instructional Leadership Supervisor of Instruction, Level 2

Professional Certificate for Instructional Leadership - School Superintendent

Professional Certificate for Instructional Leadership – Level 2 Principal, All Grades

Professional Certificate for Middle Grades Mathematics, Grades 5-9

Professional Certificate for Teaching Mathematics, Grades 8 Through 12

Student Voices on High School Math

California

Professional Clear Administrative Services (not currently active)

Single Subject, Mathematics

Supplementary Authorizations – Economics, Accounting and Computer Literacy

Awards

2012 Bluegrass Alliance for Women Lifelong Learning Scholarship - $500

1993 California School Leadership Academy – Senior Associate

Research Interests

Mathematics education
School site leadership and student achievement
Student achievement
Technology use within schools - "Flipped classroom"
School law, discipline and finance

Current Research

My dissertation is investigating the effect teacher actions and behaviors have on student achievement in high school mathematics from the student perspective.

I am also involved in research with school principals and stress.

2011 - Measures of Effective Teaching Project – Served as scoring leader for rating teachers through Educational Service in conjunction with Harvard University

Teaching Interests

Mathematics, remedial and college entry levels
Mathematics teaching
Culture, cultural development and diversity
Educational research and statistics
Inclusion, co-teaching

Student Voices on High School Math

Human resources
Mixed research methods
Principal preparation courses
Program evaluation for change
School law
Teaching methodology
Teacher leadership
Technology in the classroom
Quantitative research methods

Professional Experience

Post-Secondary Experience

2013 – present Eastern Kentucky University adjunct faculty – Remedial math, math for middle and elementary school teachers, course by special arrangement in School Leadership and Administration

2013 – present Bluegrass Community and Technical College adjunct faculty – Remedial and college level math

2011 – 2013 Eastern Kentucky University Graduate Assistant – Taught School Leadership and Administration as a class by special arrangement; Served as a teacher assistant for Introduction for Quantitative Methods as well as Cultural Leadership; Assisted faculty in the department with various projects; Served on the College Curriculum Coordinating Committee

2010 - 2011Eastern Kentucky University adjunct faculty – Taught Managerial Decision Models, School Leadership and Administration

2010 – 2013 Sullivan University adjunct faculty – Taught Basic Mathematics

2010 MedTech College adjunct faculty – Taught College Mathematics, Statistics

1990 – 1992 Victorville Community College adjunct faculty – Taught College Mathematics, College Algebra

K – 12 Experience

2008 – 2009 Consultant with Kentucky Department of Education – School Councils

2007-2008 - Middle School Mathematics Teacher, 8th grade – Winburn Middle School, Lexington, KY

2006-2007 - Principal and District Support – Frankfort High School, Frankfort, KY

2004-2006 – Principal – Goodwill Education Center – Victorville, CA – An alternative education center housing an independent study for students in grades 7-12 and a continuation high school.

2000-2004 - Assistant Principal – Victor Valley High School, Victorville, CA

2003, 1999 – Principal – Summer School - Victor Valley Union High School District, Victorville, CA

1999-2000 - Dean of Students – Victor Valley High School, Victorville, CA

1997-1999 - Dean of Students – Silverado High School, Victorville, CA

1996-1997 - Dean of Students – Victor Valley High School, Victorville, CA

1995-1996 – Administrative Substitute – Victor Valley Union High School District, Victorville, CA

1995 – Assistant Principal – Summer School - Victor Valley Union High School District, Victorville, CA

1985–1992 – Mathematics Department Chair – Victor Valley High School, Victorville, CA

1982-1996 – Mathematics Instructor – Victor Valley High School, Victorville, CA

1983-1986 – Girls Junior Varsity Basketball Coach - Victor Valley High School, Victorville, CA

Other

2010-present – Educational Testing Service – Praxis Exam Scorer – high school mathematics and the California High School Exit Exam (writing)

2014-present – Educational Testing Service – Question developer for the Praxis

Presentations

2011 Eastern Kentucky Mathematics Conference - Middle Grade Core Academic Standards in Regards to Geometry and Multiple Approaches for use in the Inclusive Classroom

2012 Eastern Kentucky Mathematics Conference – The Impact of Intangibles on Student Learning of the Kentucky Core Content Standards

2013 University Council for Educational Administration – Principal Responses to Accountability, Autonomy, and Superintendent Change: Findings From a Large U.S. Urban School District. Lead Presenter – Dr. Deborah West

Publications.

West, D, Peck, C., Reitzug, U.C., Crane, E. (in press). Principal Responses to Accountability, Autonomy, and Superintendent Change: Findings From a Large U.S. Urban School District. *School Leadership and Management.*

Additional Certificates

2008, 2011 Kentucky Teacher Internship Program – Trained both as a principal and teacher educator

2001 Professional education in the National Counseling Standards – 6 hours

2001 McGrath Sexual Harassment Investigation Program – Level 1

2001 Security Officer Instructor Course – 16 hours - Required by California to provide training to non-sworn campus security officers used in k-12 schools.

Student Voices on High School Math

1998-2006 CleanSWEEP Proctor – Program used in San Bernardino County Schools as a joint effort between law enforcement and school personnel to reduce disciplinary problems within high schools and provide community education on various issues affecting high school student populations.

2002 FRISK training – A method of documenting behaviors for school faculty and staff which was developed to support challenges to due process in corrective actions taken against faculty and staff.

1999 Powerful Discipline: Succeeding with Difficult and Challenging Students

1997 Verbal Judo training – A method to de-escalate potentially combative students

Core Competencies Include

Supervision of Attendance Office
Mediation and Resolution of Conflicts
Alternative and Traditional Secondary School Administration
IEP's and 504's
School Safety & Security, Supervision of Student Activities
Development and Presentation of Professional Development
Writing Accreditation Reports
Writing Crisis Plans
Curriculum Development and Alignment
Supervision of Curriculum Departments at School Level
Teacher Evaluation and Mentoring
Program Management and Coordination
Master Schedule Development
Inclusion in the Secondary Classroom
Collaboration to Create Success for Struggling Students
Revision of Student / Staff Handbooks
Documentation and Support for Improved Student Performance
Data Driven Decision Making

Highlights & Contributions

Developed and implemented master scheduling to support smaller learning communities.

Implemented standards based curriculum aligned with traditional schools in alternative educational setting.

Student Voices on High School Math

Increased access and success of alternative programs to better meet the needs of students.

Assisted in the design of new alternative educational school complex.

Collaborated in the development and presentation of WebEX sessions.

Supervision of security and development of PD for non-sworn security.

Trained in Crisis Intervention

Supervision and Collaboration with school staff to remove barriers to education.

Development of identifiers reflecting standards to assist with determining proficiency.

Implementation of Full Inclusion at the secondary level.

Upheld and supported commitment to educational excellence, including work with various reward programs to improve student academic achievement.

Work History – Other

November 2010 – August 2011 – Call center representative for technical support for the iPhone, iPad and iPod touch – ACS-Inc.

April 2010 – June 2010 – Census Bureau Enumerator and Assistant Crew Leader