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Rural High School Mathematics Instructional Practices and Students' Academic College Readiness

Luajean Erna Bryan
Walden University

Walden University

College of Education

This is to certify that the doctoral dissertation by

Luajean Bryan

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Review Committee
Dr. Meca Williams-Johnson, Committee Chairperson, Education Faculty
Dr. Wade Smith, Committee Member, Education Faculty
Dr. Andrew Thomas, University Reviewer, Education Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

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Abstract

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by

Luajean Nipper Bryan

MM, University of Tennessee, 1979

BS, Tennessee Wesleyan College, 1972

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Rural high school graduates in the United States lag behind in college math preparedness, therefore prompting researchers to identify instructional practices that would advance student math performance. This quantitative research study investigated specific teacher practices and their correlation with student gains in college math preparedness on the American College Test (ACT). Data were collected using a teacher questionnaire to quantify the level of reform practices among a sample of six math teachers and used ACT pre and posttests to assess 312 11th grade students' gains in college math readiness in a public rural high school in Southeast Tennessee. Correlation analysis of reform indicators from the teacher questionnaire compared the interrelatedness of six predictor variables on student math gains. The level of reform practices of the teacher was insignificant when correlated with student gains on the ACT Math subtest, $r < .1$, yet yielded important insights into rural teaching practices at the sample school. Teacher questionnaire responses indicated consistently low scores in teacher conceptual beliefs and rural connectedness, suggesting room for reform in those areas. The average Math ACT gain was 1.97 points with an average math score of 19.3. This suggests the 2016 school average will exceed the 2015 school average of 19.1 since students in the study have another year of math instruction prior to graduation. Extending the current study through college may reveal a correlation between specific teacher practices and rural student math gains.

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Dedication

I dedicate this research study to members of my family who offered words of encouragement and support at critical moments during the journey. The one person worthy of recognition above all others is my husband, Joe, who endured every crisis and celebrated every triumph along the way. Other family members who bolstered my persistence include my daughter, Mary Jane, and my granddaughters, Katie and Lauren. A special thanks is due to my son, Bob, and my daughter-in-law, Jaime, who provided celebratory words at every milestone. Last of all, I thank my grandson, Will, who afforded me dedicated time to research while he was napping.

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Chapter 1: Introduction to the Study

Introduction to Problem

Rural students in the United States generally perform at lower levels than their urban counterparts on nationally recognized tests (Crosnoe, 2009; Howley, Showalter, Klein, Sturgill, & Smith, 2013; Kim, 2010). This reality has prompted theorists to investigate why such a gap exists and motivated politicians to address the problem so that all children have equal access to a quality education. With public education under close scrutiny to meet standards and performance goals, the time is right for a study to respond to questions regarding effective instruction promoting optimal rural student outcomes. The study proposed to link instructional practices with improved student performance on tests measuring college preparedness in mathematics.

This quantitative study explored the problem of deficient college math readiness in rural students in the United States. It was designed to generate information to assist educators in preparing an increased number of STEM-ready rural high school graduates. It specifically investigated the effectiveness of reform practices grounded in constructivist theory in preparing rural high school students for college math. It also tested whether or not the socioeconomic status of rural students served as a covariant in the relationship between reform instruction and student outcomes. A rural high school in Southeast Tennessee, demographically similar to the state, participated in the study. The study focused on the effect of variable levels of reform instruction on the students' growth in mathematics over the 2014-2015 school term.

Background of the Study

Instructional practices, teacher content knowledge, and student engagement are important factors that impact student outcomes (Battey, 2013; Dodeen, Abdelfattah, Shumrani, & Hilal, 2012). School administrators in the United States expect all instructional practices are now standards-based, whether they employ reform practices, traditional practices, or a combination of both approaches. Research at special STEM schools in South Africa has demonstrated the effectiveness of transferring concrete to representational to abstract modeling in student achievement (Mudaly, & Naidoo, 2015). Teacher, administrator, and policy maker understand of the effectiveness of instructional approaches encouraged by the implementation of Common Core State Standards (CCSS) in the context of a rural environment is vital to improvements in rural education.

Situational differences in ethnicity, economics, and culture peculiar to the rural situation influences student response to instruction (Vega & Travis, 2011). Rural student responses to reform and traditional instruction yields different testing outcomes. Rural education in the Southern region of the United States shows potential for significant improvements as educators and policymakers work to agree on the needs of students (NGA, 2012). The adoption of CCSS and accountability measures helps standardize the instruction and ensure equal access while it is essential to maintain high regard for the cultural heritage of communities. Place-value and cultural sensitivity are particularly important entities for consideration for educators to connect with students (Hardre, 2012; Howley, 2009; Park, Holloway, Arendtsz, Bempechat, & Li, 2012). Wilcox, Angelis, Baker, & Lawson (2014) concluded from a multiple case study contrasting high performing and low performing high schools in New York state that educator sensitivity to rural communities and the needs of rural students contributed to statistically signficant increased graduation rates and college readiness.

Impact of Poverty on Performance

Another prevalent obstacle to education in the rural South is poverty (Baker & Johnston, 2011). A recent study in Texas concluded that economically disadvantaged students demonstrated less college readiness than students who were not disadvantaged (Lee & Slate, 2014). It is increasingly important to consider socioeconomics when researching the effectiveness of reform instruction in the rural context.

Focusing on the resources at hand and placing value on the anomalies of the rural culture enables educators to make progress despite the high poverty and economic conditions of a community (Wilcox, et al., 2014). Maintaining high standards, promoting family values through close communications, and capitalizing on the resources at hand can lead to higher expectations from families and students. Excessive focus on what resources are missing and what obstructions to learning exist thwarts any efforts to improve. According to the four-year Wilcox study of 1,114 high schools between 2009 and 2012, poverty-stricken schools that thrived academically placed a high priority on high expectations and professionalism. Poverty need not be the determining factor in whether a school is high or low performing.

Identified Gap in Knowledge

Most extant research regarding reform practices and their effects on student outcomes in the United States has been conducted with elementary or middle school students. Ten research studies from the past five years focused on rural or economically disadvantaged elementary or middle schools and their moves toward reform. Two studies in the same time frame focused on reform in Grades 9–12. Multiple researchers have suggested that further study is needed regarding rural high school students for a complete picture of the effects of various curricular and instructional reforms (Grady, Watkins, & Montalvo, 2012; Gresalfi, Barnes, & Cross, 2012; Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010; Kim, 2010; Middleton, Leavy, & Leader, 2013; Vogler & Burton, 2010). Implications from these studies are that elementary students respond quickly to change and secondary students, accustomed to traditional instruction, acclimate slowly to changes in instruction.

Previous research regarding the effects of different transitional curriculum resources has focused on students in middle school programs or teachers in transition who incorporated various levels of reform practices for high school students. Researchers have suggested extending this research to target the effectiveness of instructional strategies in high school mathematics where students often fail to see relevancy, become disengaged, and favor friends' perceptions of their competency in mathematics (Jones, Irvin, & Kibe, 2012; Park, Holloway, Arendtsz, Bempechat, & Li, 2012; Vega & Travis, 2011). Quantitative studies about college readiness of rural high school students with variable learning experiences can fill the gap in information regarding instructional practices leading to improvements in academic achievement of rural students. My study involved rural students from the same high school who experienced different levels of reform instruction from different math teachers. The study in contrast to others, focused on improvements in math college readiness following a year of math instruction of variable reform measures.

Problem Statement

Children in the United States who grow up in poverty are less likely to have access to quality education (Max, Glazerman, & National Center for Education Evaluation and Regional Assistance, 2014). Rural areas in the Southern United States are more likely to also be high poverty areas Educators in rural areas prone to high poverty are confused about which teaching strategies work best and are concerned with giving equal opportunities for learning to all students. The performance gap between rural and urban sectors in the United States suggests that students respond to different instructional approaches as appropriate for their particular situations.

Reform Education Targets Inequalities

Speculation about inequities in education in rural and urban areas has led to reforms in instruction and assessments with intentions of eliciting improvements in achievement of rural students. Reforms have focused on quality instruction that promote student achievement in order to narrow the performance gap between urban and rural students. According to Early, Rogge, and Deci (2014), assessing quality instruction requires attention to student engagement. Wedin (2014) adds that rigor for all students and alignment with curriculum are vital to ensure equitable education. Reform instruction is attentive to all three constructs with innovative designs (Wedin). Some schools encourage implementation of *flipped* classrooms, an extreme reform design that incorporates the discovery and socially interactive learning style deemed effective with students (Clark, 2015; Ng, 2014). Student-centered learning is at the heart of all reform mathematics instruction. Keeping abreast of the changing curriculum and pressing for optimal test performance, teachers may lose sight of the main goal of encouraging what is best for students' learning situation unless policy makers and educators agree what instructional approaches truly meet the needs of rural students.

Purpose of the Research Study

This study investigated the effectiveness of different instructional practices on student outcomes in mathematics in a rural high school in the Southeastern United States. For the purpose of this study, effective instructional practices in high school mathematics are those practices that engage the student in learning, inspire creativity in problem-solving and promote college math readiness. The study investigated whether optimal student scoring on nationally recognized tests measuring college academic readiness depended on instruction based entirely on reform practices, or entirely on traditional practices, or a blend of both practices. The focus of this research study was on rural student outcomes relative to the students' classroom experiences during the learning process.

Theoretical Framework

Traditional practices of lecture, textbook assignments, practice, review, monitoring, and assessing are under reform as teachers incorporate social interaction, inquiry learning activities, technology for investigative purposes, and open-ended problem solving in real world contexts. Productive peer culture, promoted by student discourse, is unlikely to evolve in a mostly traditional classroom (Grant, 2014).

Constructivist theory supports incorporating new instructional strategies such as images to promote discussion prior to instruction (Kates, Byrd, & Haider, 2015), use of interactive technology to promote student engagement through modeling (Lagrange, 2014), and a relevant curriculum through integration of other subjects (Cress, 2013). The revitalization of standards across the nation has focused on critical thinking skills, problem-solving experiences, mathematical discourse, technical skills, and ongoing, varied assessments. Research at the primary grade levels, kindergarten through Grades 1 and 2 (Firmender, Gavin, & McCoach, 2014), revealed positive student outcomes following effective use of mathematical communication to facilitate student understanding. The Common Core State Standards (CCSS), designed to prepare students for college, aimed to create more equitable education for all students through better training for teachers and quality implementation of reform instruction.

It is essential that teachers receive training in reform strategies, such as writing in mathematics classes, in order to be able to use these strategies effectively (Kuzle, 2013). Intensive training of teachers in rural Appalachian schools (Barrett, Cowen, Toma, & Troske, 2015) yielded positive student outcomes in grades K-12 with benefits extended beyond the year of the training. Across the Southern states educators are restructuring courses, rethinking curricula, and modifying instructional practices to better align with CCSS or with the state's equivalent standards (Obara & Sloan, 2010; Saunders, Bethune, Spooner, & Browder, 2013; Vega & Travis, 2011; Vogler & Burton, 2010). A study of the effects of different instructional practices on student outcomes within the rural cultural context may suggest effective practices for educators in rural schools. A quantitative study comparing student outcomes following different levels of reform instruction may provide answers to the effectiveness question.

Research Questions

The research study addressed one primary and one secondary question regarding the relationship between rural student outcomes in mathematics, the dependent variable, and the instructional practices used in the classroom, the independent variables. The primary research question for this study (RQ1) was: What differences exist between rural student outcomes in mathematics following reform, traditional, or a blend of instructional practices as determined by assessments measuring college academic readiness?

RQ1 had two associated hypotheses:

- $H1_O$: There is no statistically significant difference in the Math ACT subtest score for rural students receiving traditional, reform, or a blend of both math instructional practices.
- $H1_1$: There is a statistically significant difference in the Math ACT subtest score for rural students receiving traditional, reform, or a blend of both math instructional practices.

The secondary research question for this study (RQ2) was: How do reform and traditional math instruction impact rural students of low SES compared to rural students of high SES in regard to college math readiness?

RQ2 had two associated hypotheses:

- $H2_O$: There is no statistically significant difference in the ACT math subtest scores for rural students of low socioeconomic status and those students not of low socioeconomic status following math instruction that is traditional, reform, or a blend of both practices.
- $H2_1$: There is a statistically significant difference in the ACT math subtest scores for rural students of low socioeconomic status and those rural students not of low socioeconomic status following math instruction that is traditional, reform, or a blend of both practices.

Influences on the Condition of Rural Education

Education is impacted by ethnicity, region, and poverty level (Aud et al., 2013). This link suggests that specific characteristics of the learning process are also subject to ethnic, regional, and socioeconomic factors. Because of this potential influence, it is important to test teaching practices effective in other regions of United States to determine whether they are or are not the best practices for securing optimal student outcomes in rural public high school mathematics classes. United States educational researchers have not previously examined the place value of diverse locales in part due to a national focus on consumerism, global competitiveness, and test performance (Barter, 2014). This makes it unclear whether or not attributes of the rural United States will contribute to learning of mathematics rather than inhibit the experience when educators focus on relevancy and the potential for improvement of the rural community (Howley, Showaler, Klein, Sturgill & Smith, 2013). Individual interactions between teachers and students contribute significantly to the learning process (Kenyatta, 2012), making it important to examine if the particulars of that exchange can be modified to further motivate engagement, promote learning, and optimize outcomes. This study was designed in part to examine rural students' preparedness for college following different instructional approaches and determine if particular strategies effectively improve rural high school students' preparedness for college.

Education in the rural South. Rural schools are predominant in the American South, where poverty is prevalent. Poverty, according to the National Census Bureau, is defined as having an annual income for a family of four below the threshold of $22,811 in 2011. Twenty-one percent of children aged five to 17 years were living in poverty in the United States in 2011; in the American South, this measure was 23% (Aud et al., 2013). Fifteen of the 50 U.S. states and the District of Columbia have poverty rates above the national average; 12 of these 16 areas are in the South (Aud et al.). Tennessee, where the study site was located, is among the most impoverished states in the South.

Multiple studies have shown that students at public schools in areas that are predominately filled with residents of low socioeconomic status perform lower on various achievement tests (Baker & Johnston, 2011; Brown, Schiller, Roey, Perkins, Schmidt, Houang, & Westat, 2013; Carbonaro & Covay, 2010). Consideration of the socioeconomic level of students in the 2015 study was important to respond to questions regarding the influence of poverty on learning response to reform instruction. The concentration of public school students living in poverty across the rural South underscores the severity of the problem.

Testing mandates. Many Southern states, including Tennessee, faced common core standards-based assessments in 2014-2015. As a first round recipient of the Race to the Top (RTTT) funding in 2009, Tennessee initiated implementation of CCSS at the elementary and middle school levels in that same year, with subsequent high school implementation in 2010. Tennessee has realized full implementation of CCSS in Tennessee K-5 and middle schools over a five-year period, 2010 to 2015, and gained much national attention with recent student testing outcomes (SCORE, 2015). Tennessee's Grades 4 and 8 experienced notable gains in test scores as indicated on the National Assessment of Academic Progress (NAEP), leading the nation in the greatest improvement in 2013 (SCORE, 2014). While Tennessee's scores are still below the national average (Vigdor, 2013), Tennessee's Governor Haslam attributed the unprecedented test score gains to the standardization of curriculum and instruction achieved through CCSS (SCORE, 2014). However, in 2013, Tennessee's high school students did not demonstrate the same measure of improvement.

Although Tennessee had a state-wide graduation rate of 86% in 2014 only 15% of Tennessee's high school graduates demonstrated college readiness on the American College Test (ACT) (SCORE, 2014). These dissimilar results have generated additional questions about the effectiveness of reform instructional practices and the impact on high school student outcomes. The question of effective practices toward student outcomes is amplified in mathematics. According to recent research, less than a quarter of the nation's high school graduates are deemed college-ready in math by the ACT (Bragg & Taylor, 2014). An increase in math remediation at the college level underscores the ill-preparedness of students for college-level math (Barnett, Fay, Bork, & Weiss, 2013). Additionally, Tennessee high school students are below the national NAEP average, and the state NAEP average in math for 12th-graders has revealed no significant change for several years (NAEP, 2013).

Standards. Tennessee high school students and teachers have been held accountable to state standards during the transition into CCSS. State-mandated end-of-course tests in Algebra 1 and Algebra 2, which were aligned with Tennessee state standards for those courses, ended in the spring of 2014 for most school systems (TDOE Academic Standards, 2014). Beginning in 2016, Tennessee students will face newly modified standards expected to be a hybrid of CCSS and Tennessee state standards, aptly named TNReady (TN DOE, 2015). At the time of this study, Tennessee educators were restructuring their high school mathematics curriculum and instructional approaches to more closely align with CCSS and TNReady Standards as these new standards become available (TN DOE Core Values, 2014; TN DOE Assessments, 2015).

As a result of this change, some Tennessee high schools, including the one where the research study was conducted, have elected to replace the traditional Algebra 1, Geometry, and Algebra 2 courses with Integrated Mathematics 1, 2, and 3 courses. Schools making this election have the option to request a waiver from CCSS testing during their first year of transition into the integrated mathematics curriculum. Upon receiving state approval, those schools will continue to test on state standards during the year of transition into integrated mathematics while attending to both Tennessee state standards and CCSS. New legislature introduced in Tennessee intends to disconnect from CCSS, although educators expect the TNReady Standards to resemble CCSS with a narrowed scope of testing criteria.

Transition into reform standards. To assist the transition into reform standards, leaders across Tennessee are continuing to train secondary mathematics teachers and supervisors in use of reform instructional practices emphasizing critical thinking, reflection, and analysis skills for learning mathematics. Not all teachers and systems have fully embraced reform practices. The varied levels of buy-in from teachers and the individual interpretations of reform practices lead to less than robust implementation in many schools. The link between learning principles and standards implementation is often blurred in practice (Gilliam & Gilliam, 2014). A study of teachers attempting to adopt reform pedagogy revealed inherent struggles with planning standards-based activities rich in mathematical content and open to student exploration (Lewis, 2014).

Teaching practices in U.S. classrooms are diverse. Traditional practices still exist in many U.S. classrooms, a blend of traditional and reform practices in some classrooms, while exclusive reform instructional practices are in place in others (Lawrence & Sanders, 2013). Insufficient training, lack of access to technology, shortages in funding, and individual teacher interpretation of best practices may impede consistency in implementation of reform practices as research suggests (Lawrence & Sanders). Research (Dornisch, 2013; Gu, Zhu, & Guo, 2013) indicated a notable gap between student and teacher knowledge of technologies that often inhibits integration of technology into instruction. Lack of understanding and inadequate training in the reform instructional practices in rural secondary mathematics have led to differing levels of persuasion of teachers to abandon their traditional practices in favor of new and innovative instructional practices (Duffy, Park, RFA, 2012; Obara & Sloan, 2010; Vogler & Burton, 2010). Though all Tennessee teachers have received Common Core training, either directly through training institutes across the state or indirectly by teachers carrying the training back to their individual schools, many Tennessee math teachers are adjusting to the fundamentally different approach to teaching and learning. This hesitancy toward full adoption of reform instructional strategies may, in practice, yield improved results suitable to the adaptability of schools, teachers, and students as teachers use their own keen insights into what is working best for their students. This study intended to illuminate the potentialities of traditional, reform, or a blended instructional approach toward improved student outcomes to inform teachers in rural schools of effective practices in the rural learning context, specifically in high school mathematics.

Anomalies of Rural U.S. Culture

The complex nature of the rural culture creates a particular learning context where the interactive relationship between students and teachers becomes vital to successful outcomes for students. The nature of the rural culture causes teaching and learning to have variable levels of importance to students and communities. Though schooling is viewed as important, home and family values often conflict with educational values taught in school (Hendrickson, 2012; Howley, 2009, Kyle, 2011).

Studies have uncovered various notions regarding the learning capacity of rural students. Research on elementary and middle school learners in rural schools indicates that student learning is connected to teacher instructional practices (Baker & Johnston, 2011; Battey, 2013; Grady, Watkins, & Montalvo, 2012; Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010). Similar studies at the secondary level in the U.S., as well as internationally, indicate there are social and psychological reasons for failure of rural high school students to engage in learning as expected (Buckley, 2010; Crosnoe, 2009; Hendrickson, 2012; Jones, Irvin, & Kibe, 2012; Park, Holloway, Arendtsz, Bempechat, & Li, 2012). The interactive communication between the community and the school are vital to optimize the educational experience (Totan, Ozyesil, Deniz, & Kiyar, 2014). These notions contribute to the need for a current study linking rural student college math readiness and teacher instructional practices and motivated my study.

The learning of mathematics is particularly hampered by the perceived abstractness of higher mathematics that does not translate as useful in the rural context. Students may be reluctant to take higher level mathematics courses in high school when the courses seem irrelevant to their world (Battey, 2013; Hardre, 2012; Hendrickson, 2012; Park, Holloway, Arendtsz, Bempechat, & Li, 2012). Students leave high school unprepared for college math at alarming numbers reflected in the high percentages of those needing remediation prior to earning college credits, according to a recent study in Texas (Abraham, Slate, Saxon, & Barnes, 2014). Remediation levels are high in mathematics for many community colleges. The disconnect between students and mathematics is even more apparent at the secondary level than in grades K-8, as evidenced by the recent gains in NAEP by Tennessee's fourth and 8th graders while the twelfth graders showed no such gains (NAEP, 2013, 2014). Recent studies on secondary schools cited such rural anomalies as lack of relevance (Hendrickson, 2012), lack of prior success in mathematics (Davis, 2011), student perception of competency in mathematics (Pyzdrowski, Sun, Curtis, Miller, Winn, & Hensel, 2013; Strayhorn, 2015), teachers' lack of cultural sensitivity (Strayhorn), teachers' structure of the learning experience out of sync with the rural experience (Waters, Howley, & Schultz, 2010), and other rural life experiences as interruptive to the learning process (Shuffleton, 2013). There appear to be specific issues of teaching and learning of mathematics peculiar to the rural situation (Waters, Howley, & Schultz). This study intended to provide data that linked rural student outcomes with level of reform practices experienced, including the rural connectedness of the teacher.

The rural awareness of the teacher, quantified in the responses to survey questions, predicated the connection of math lessons with the community to incorporate place value. Just as the effectiveness of different instructional practices varies according to geographic region, cultural diversity, and socioeconomic level, cultural sensitivity involves an awareness of the economics, family values, and cultural traditions leading to student success. An understanding of the effectiveness of teachers and their instructional practices in high school mathematics in the rural context is essential to optimize the learning experience of students situated in the rural culture and often deprived of quality education due to limited resources, conflicting educational values in the school and home, or student disengagement due to perceived irrelevancy of the mathematics content (Battey, 2013; Hardre, 2012; Hendrickson, 2012; Howley, 2009; Park, Holloway, Arendtsz, Bempechat, & Li, 2012). Robust reform must addresss rural issues (Blanton & Harmon, 2005; Harmon & Smith, 2012). The variable levels of reform instruction in math classes in the sample school had a broad range but the rural connectedness of the teachers reflected a narrow margin or scoring from the participants.

Teacher relationships with rural students provides a powerful influence on their learning causing the manner of implementation of instruction to be just as important as the choice of curriculum or content. The power of the relationship between the teacher and the student cannot be underestimated when assessing the teaching and learning process (Battey, 2013; Gresalfi, Barnes, & Cross, 2012; Harmon & Smith, 2012; Schonfeld, 2009). The study did not address the relationship between students and their teacher beyond quantifying the rural connectedness of the teacher. Whether teachers build positive relationships, use reform strategies as intended, or understand the rural situation in which they teach, rural students and urban students have performance expectations. The rules of engagement may vary for different sectors of students or different teachers while the measure of outcomes remains constant: test results.

Significance of Reform Efforts in Rural Initiatives

Preparing rural high school students for college is increasingly more important to the welfare of our nation as the increased need for scientists, engineers, and technically skilled professionals surpasses the projected national supply. Teachers are adjusting their practices to better prepare rural students for college and career entry. There is much work ahead to improve rural high school performance in mathematics. This research intended to illuminate the effectiveness of different instructional practices toward improving rural student outcomes. When graduates are ill-prepared for college they are less likely to be prepared to fill the need for science, technology, engineering, and mathematics (STEM) careerists. Students with low test performance are less likely to enter college or pursue STEM careers. Recent efforts toward integration of STEM into the K-12 curriculum has focused on both content and context integration (Moore & Smith, 2014) intended to incite STEM awareness, student engagement with increased access to STEM careers. Successful efforts with specialized STEM schools have focused on immersion and a collaborative learning environment (Erdogen & Stuessy, 2015). STEM initiatives in the sample school were part of the Tennessee STEM Innovation Network (TSIN) designed to respond to the shortage of prepared math graduates. Secondary schools, as well as elementary schools across Tennessee, have developed STEM awareness through participation in TSIN. Extensive training efforts with science and math teachers to revitalize curriculum include increased community involvement, local problem solving, and place based learning opportunities that integrate course content.

Changes initiated at post-secondary institutions have embraced evidenced-based teaching approaches to generate interest in STEM from weaker students and those considered nontraditional STEM students (Mulnix & Vandegrift, 2014). The preferred learning style of engineering students is a reform design that focuses on kinesthetic or visual learning, while the popular teaching style of engineering teachers is verbal (Katsioloudis & Fantz, 2014). Matching teaching style with the learner is important for optimal learning. Both college and technical career paths show greater promise for high income and successful career engagement (Howley, 2009; Rothman, 2012; Schoenfeld, 2009; Tsai, C., Shen, &Tsai, M., 2011). This leads to the supposition that improved outcomes are vital in the rural regions, particularly in the southern United States. The study in Tennessee paid particular attention to the impact of teaching style and student college math readiness.

Tennessee Student Outcomes

At the time of this study, only 15% of Tennessee's high school graduates demonstrated college readiness in all core subjects based upon their ACT scores (SCORE, 2014) and the 2014 ACT reported that 19% of Tennessee's students met benchmarks in all core subjects (ACT, 2014). The 2015 ACT reported that 30% of Tennessee's students met the benchmark for college readiness in math, compared to 40% of the nation's students (ACT, 2015). Tennessee's governor attributed the recent increase in Tennessee's college readiness to the rigorous standards in place and the increased teacher efforts toward student engagement (TN newsroom, August 20, 2014). Though Tennessee's Math ACT scores are far below the national average, bear in mind that, since 2009, Tennessee is only one of 12 states testing 100% of their students on ACT. Among those 12 states, Tennessee ranked 10th in average composite ACT score in 2014 (Garrison, 2014). Prior to 2009, fewer states tested 100% of their graduates. The diagram in figure 1 displays the average Math ACT scores for the nation, for Tennessee, and for the other states testing 100% of their graduates. Beginning in 2009 twelve states, including Tennessee, have required 100% of their graduates to take the ACT. Testing 100% of the students explains the abrupt drop in Tennessee's average Math ACT score from 2009 to 2010. The drop was sharper for other states than for Tennessee. These ACT math subtest average scores indicate an overall lack of academic readiness for college math across the nation, with severe unpreparedness in Tennessee.

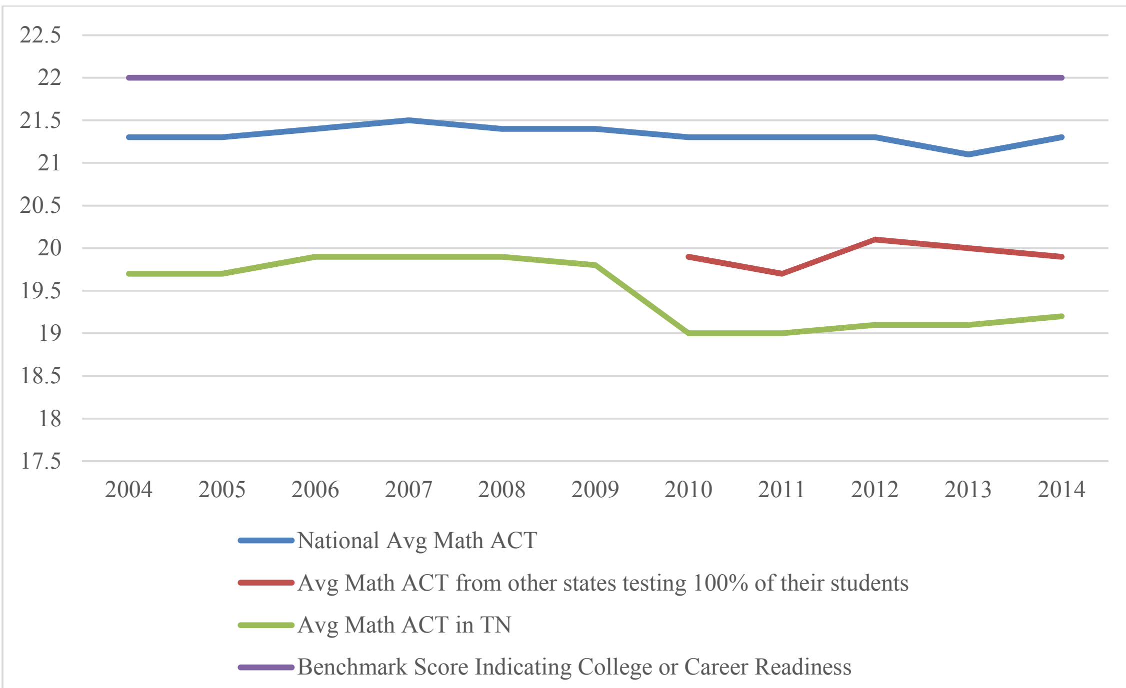

Figure 1. Average ACT Mathematics Subtest Scores 2004 – 2014 compares the average Math ACT scores for graduating seniors of those respective years. (The American College Test, 2014a. The condition of college & career readiness in Tennessee, 2014. Retrieved from http://www.act.org/readiness/2014.

The horizontal line on the graph represents the benchmark score of 22 for predictive success in college algebra. It is evident that Tennessee has not performed well on the mathematics ACT in comparison to other states. The national average composite Math ACT score for 2015 was 21.0 and Tennessee's average composite score for the same year was 19.8 (ACT 2015). While this score appears close to average, Tennessee ranked 9th among the states that tested 100% of their students. Reform practices may be impacting student performance. In 2015, Tennessee's students made their highest gains in five years toward reaching ACT college readiness benchmarks (TN DOE, 2015).

Recent emphasis on college readiness and the governor's initiative to permit tuition-free community college for residential Tennessee graduates (TN Department of Education, College Pays, 2014) may motivate an increase in mathematics achievement. Researchers (Schneider, Broda, Judy, & Burkander, K., 2013; Venezia, & Jaeger, 2013) concurred that mentoring programs assist student transition from high school into college. This additional emphasis on college preparation may promote college readiness like the early college high school program in Texas that successfully prepared an increased number of STEM-ready graduates (Chapa, Galvan-De Leon, Solis, & Mundy, 2014). Additional research by Wang (2013) posited the importance of additional supports for integrating STEM-interested students into college programs.

Often, challenging mathematics is the gatekeeper to technical and professional careers. This realization forces lawmakers and policy makers and corporate executives to encourage higher mathematics leading to Science, Technology, Engineering, and Mathematics (STEM) careers. This thrust toward higher achievement in mathematics has caused educators to reevaluate and restructure their teaching practices to produce more successful student outcomes (Duffy, Park, & RFA, 2012; Hardre, 2012; Lawrence & Sanders, 2012; Tutak, Bondy, & Adams, 2011). The increasing employment demand for STEM ready employees forces Tennessee employers to search outside the state and region for qualified applicants.

The projected supply for STEM careers in Tennessee in the future does not meet the projected demand (University of TN, 2011). There is potentially a rich untapped resource of mathematical and scientific talent among Tennessee's students but they are leaving high school unprepared for the demands of college and career. Though politicians and the general public often hold teachers and schools accountable for this unpreparedness, there may be contributing factors in the rural context that impede the rural student's desire to perform or an absence of teacher understanding of the rural context. Characteristics of the rural culture that affect the teaching and learning process, if identified, can be leveraged to improve the condition of rural education (Battey, 2013; Davis et al., 2011; Davis, Burnette, Allison, & Stone, 2011). It is beneficial for educators to understand the rural context of their students in order to know the best approaches leading to positive student outcomes. Leveraging the complex cultural values and interdependence of rural communities toward betterment of the rural existence through increased education may incite rural students to become agents of change for their communities.

Significance of the Study

The issue of national competitiveness is apparent to the world as the United States lags behind other industrialized nations in science and mathematics on the high school NAEP test (NAEP, 2013). The status of the United States when comparing NAEP scoring may be viewed as a weakness in scientific competitiveness or national defense or low accountability of American taxpayers (Good, 2010). Test performance gains are important in the political domain since test scores are the common comparison metric of national prowess in industry, technology, and global positioning. The drive to improve education has precipitated recent governmental reform interventions toward increased accountability of students and teachers (Eacott & Holmes, 2010; Kessinger, 2011; Kober, Rentmer, & CEP, 2011; NAEP, 2013; & SCORE, 2014). Economic issues are not the only incentive for improvements in education. Ensuring equal opportunities to higher quality of life for all students through relevant, quality education is the primary objective of public education in the U.S. The pursuit of a better civic-mindedness challenges the nation toward excellence in education for all students. Identifying instructional practices that motivate positive gains for rural students may assist this endeavor.

Nature of the Study

The research study was a quantitative study investigating the correlation between instructional practices and student ACT math subtest scores. Supportive research had no prior statistical evidence that reform programs bolstered academic performance for high school students but no study focused on college readiness. The investigation targeted a representative high school where use of reform and traditional practices, as well as a blend of practices coexisted. The research study involved collection of student performance data relating college readiness before and after the reform/traditional instruction. The researcher planned a teacher questionnaire to measure the level of reform/traditional instruction so that statistical analyses using various correlation tests could detect effects of the various constructs of reform instruction.

Expediency of the Study. The timing of this study was important to immediate decision-making at all levels. Recognizing which instructional practices contribute to improving rural high school student preparedness for college informs decision-making at the local, state, and national levels. Curriculum selection, teacher training, and leadership directives hinge on the effectiveness of teachers to produce gains in student outcomes. The current focus on standards-based instruction has shifted instructional practices toward greater use of technology wherever feasible, renewed emphasis on critical thinking skills through collaborative learning guided by standards trained teachers, and increased attention to test results and teacher evaluation results.

Factors Impacting Rural School Performance

Research regarding the problem of low performance in rural high school mathematics has revealed inconclusive findings. Though most studies conclude that poverty is a major factor in student performance in rural high schools (Aud et al., 2013; Baker & Johnston, 2011; Battey, 2013), others suggested there are far-reaching cultural phenomena peculiar to the rural situation that impact the learning capacity of rural learners in secondary mathematics classes (Tutak, Bondy, & Adams, 2011; Davis et al., 2011). The CCSS and most state standards do not address cultural differences as the standards are the same for all different sectors of the learning population. Providing equity and access to education may be a primary objective of standardization but it may overlook an inherent possibility: different sectors of society may respond differently to different instructional strategies. Though students share many commonalities across cultural barriers, their optimal learning environments may not be identical. Differences in home situation, differences in cultural values and background, feelings regarding relevancy of the material in the classroom, and different levels of adult support may alter their capacity to respond in the scripted learning environment (Davis et al., 2011; Hardre, 2012; Hendrickson, 2012; Howley, 2009). Rural students hold family and home values in high esteem and the home education resources and a culturally supportive school environment are two important variables impacting student achievement in rural schools (Alkyuz & Berberoglu, 2010; Park, Holloway, Arendtsz, Bempechat, & Li, 2012; Battey, 2013; Davis, 2011; Dodeen, Abdelfattah, Shumrani, & Abu Hilal, 2012; Hendrickson, 2012; Tsai, Shen, & Tsai, 2011). Some studies were from Turkey and European countries (Alkyuz & Berberoglu), one from California (Park et al.), two from Saudi and Taiwan (Dodeen et al.; Tsai et al.), and another from Appalachian Ohio (Hendrickson, 2012). Situational factors in other countries or states across the nation may be similar to those in the rural South. Successful reform strategies implemented by mathematics teachers in other rural regions may be helpful to mathematics teachers in rural high schools across the Southern United States.

Another rural anomaly repeated throughout the research, from primary grade students all the way up to college level students, was the importance of the relational interaction between teacher and students essential for student engagement and learning (Battey, 2013; Crosnoe, 2009; Davis, 2011; Jones, Irwin, & Kibe, 2012; Obara & Sloan, 2010; Olteanu & Holmqvist, 2012; Park, Holloway, Arendtsz, Bempechat, & Li, 2012). Research suggested that the relational interaction was not as valuable to the learning experience in higher socioeconomic settings or urban schools as it was in rural schools. Researchers reasoned that student-adult interactions are fewer in rural areas and the emphasis on relationships between students and teachers is more critical to student engagement. Most research agrees that teacher impact is of primary importance in the long-term success of the student (Ballou, 2012) but not enough is known about teacher practices to leverage positive impact.

The promise of college readiness may sound like a positive hope while the enigma of public education does not evoke a consistent response from those in the rural sector. Not all rural students have familial adults who value education or technical training beyond high school (Hendrickson, 2012; Howley, 2009). Keeping students within their home community, a common objective of rural culture, is threatened by advancing education that may lead to distant work opportunities. Building social capital within the community that allows students to envision work opportunities to build their own community may require high school educational experiences where students see the potential for such endeavors (Hardre, 2012; Hendrickson, 2012; Howley, 2009). The peculiarities of the rural culture are complex and can either be supportive or a barrier to the high achievement of the rural student in today's high school mathematics classroom. Rural schools with high percentages of economically disadvantaged students have fewer students attend college than their urban or suburban counterparts (Howley Johnson, Passa, & Uekawa, 2014). Recognizing effective strategies toward leveraging social capital and cultural values toward higher achievement in the classroom may enable teachers to effect positive academic gains in mathematics for students in rural areas, particularly for those economically disadvantaged students.

Summary of Research Literature

Motivation is fundamental to learning. This central theory permeates learning theory from early Piagetian educational theory to the present reform era. The relevancy of

Piaget's learning theory today is found in the reform emphasis on logic and sequential learning (Wavering, 2011). Learning theory substantiating the proposed study includes Piaget's (1928) cognitive development, and Vygotsky's (1981) social constructivism regarding interactive relational behavior among students and between teachers and students. Theories that learning relies on motivation and motivation relies on relevancy (Von Glasersfeld, 1989) incorporate both cognitive and social constructivism. Middle school research (Gilbert et al., 2014) concluded that it is essential to have continuous professional development focused on student motivational strategies leading to positive outcomes (Krawec & Montague, 2014). To assure effective use of digital technologies, researchers (Laurillard, Charlton, Craft, Dimakopoulos, et al., 2013; Voogt, Knezek, Cox, Knezek, & ten Brummelhuis, 2013) recommended on-going professional training for development of pedagogy and a blended approach to instruction. Reform instructional practices promote the interactive nature of reasoning and sense-making through peer interaction, substantiated by theories posed by Shoenfeld (2004). Piaget's theories on cognitive development support the reform emphasis on problem-solving through logical reasoning. His theory proposed that students be encouraged to self-check, approximate, reflect and reason as the teacher serves as a facilitator and guide (Piaget, 1928).

The use of social exchange to enhance learning is not new to educational theory since Vygotsky introduced social constructivism in the last century. Recent advances in social media through digital access have developed this theory further. Student discourse as a learning activity is supported theoretically by Piaget (1928), Vygotsky (1981), Shoenfeld (2004; 2009), and Von Glasersfeld (1989). Student engagement in the learning process ensures a higher level of achievement. Vygotsky's and Piaget's -promotion of self-regulation and metacognition during the learning process (Fox & Riconscente, 2008) align with current reforms in mathematics instruction. The rapid increase in technology as a support mechanism in the classroom (Shirley, Irving, Sanalan, Pape, & Owens, 2011; Sorensen & Levinsen, 2015) relies on the theoretical framework of cognitive and social constructivism.

The learning environment of the rural school may have extenuating circumstances of limited internet access, less technologically trained teachers, and limited funding toward correcting these two inadequacies. Meanwhile, students are engaging in digital learning in increasing numbers (Hoffman, 2013; Sorensen, & Levinsen, 2015). Literature supports a restructuring of the system to incorporate digital technologies into classroom instruction (Davis, Eickelmann, & Zaka, 2013). Educational theories support student engagement, reasoning and sense making through student reflection and discourse, two vital components in the development of operative knowledge (Piaget, in Vygotsky, 1981). Implementation of these theories into high school mathematics instruction may depend on the teacher's understanding of the learning process. Literature supports reasoning and sense-making and essential critical teacher questioning skills in reform math instruction (Mueller, Yankelewitz, & Maher, 2014).

Researchers concur that rich discourse in the mathematical sciences enhances the learning experience by promoting critical thinking (Gul, Khan, Ahmed, et al, 2014; Lewis, Baker, Watts, & Lang, 2014). Reform instructional practices have theoretical grounding, while some practices merit serious consideration as educators determine what is best for their individual students. Researchers posited improved student learning with increased use of formative assessments fitted to rubrics to improve learning (Kinne, Hasenbank, & Coffey, 2014; Lipnevich, McCallen, Miles, & Smith, 2014). Other researchers (Hannah, James, & Williams, 2014) encouraged computer-aided formative assessments after their New Zealand study reported improved student summative assessments.

Other researchers (Jacoby et al., 2014) agreed that the instant formative feedback provided by technology was invaluable. Targeted, graduated interventions, recommended by Dobbins, Gagnon, & Ulrich, (2014) and Fuchs, Fuchs, & Vaughn, (2014), produced positive student outcomes in practice. Response to intervention strategies requires intense planning and professional training (Robins, & Antrim, 2013). Howery, McClellan, and Pedersen-Bayus (2013) recommended a structured approach to planning effective interventions. Well-planned interventions do not marginalize at-risk groups through lowered teacher expectations or compromised rigor.

Cultural sensitivity, strong content knowledge, and genuine concern for students are essential characteristics of effective teachers, particularly in high poverty schools (Morgan, 2012). The creative endeavor to customize instructional practices to the rural context may open mathematics learning opportunities to a larger audience of rural high school students. Including a measure of cultural awareness in the survey instrument was essential in order to acknowledge these recent research efforts.

Definitions of Terms

Traditional instructional practices shall refer to those teacher practices of lecture, teacher examples, independent student practice, assignments, review, and assessments. Reform instructional practices shall include teacher facilitated problem-solving, student investigative activities, peer collaboration, project-based learning, relevant contextual applications, and student discourse. Both instructional approaches may include technology while the manner in which technology is used shall distinguish whether it is for traditional practice and review or a reform practice for investigative purposes. The role of the teacher, the competency level and mindful integration of technology into the learning process impact the usefulness (Drijvers, 2013).

Effective instructional practices shall be defined as those practices used by teachers that lead to improved student performance on college readiness tests. The focus of this study shall be on student outcomes following practices used by teachers in high school mathematics in rural high schools of Tennessee.

Elementary and middle schools shall refer to public schools providing grades kindergarten through 5th grade and 6th grade through 8th grade, respectively.

High school shall refer to grades nine through twelve. Mathematics classes shall refer to the core subjects of algebra I, geometry, and algebra II, with student choice of the fourth mathematics course required for graduation in Tennessee.

Rural shall refer to a low-density populated area, as described by the U.S. Census Bureau (2010), wherein a remote socio-culture thrives (Koziol, Arthur, Hawley, Bovaird, Bash, McCormick, & Welch, 2015). The U.S. Census Bureau (2010) defined rural territory as that which is more than five miles, yet less than 25 miles from an urban area. This description applies to the high school community of the current study.

Standards-based instruction in high school mathematics shall refer to mathematics instruction addressing the CCSS and/or state standards connected with Tennessee Consolidated Assessment Program (TCAP) end of course (EOC) testing. In the school year 2014-2015, testing in Tennessee will involve algebra I and II (TN DOE: Assessments, 2014).

Low socioeconomic levels defined by the United States Census Bureau (2013) are set according to terms of poverty levels. In 2013 the threshold of poverty for a family of four was designated as those families whose annual income was no more than $22,811 (Aud et al., 2013). Low socioeconomic status for students is indicated in school data bases as those students who qualify for free or reduced lunch programs due to falling at or below poverty level for the current year. Although the Census Bureau does not vary the threshold of poverty geographically across the nation, there is disparity in average incomes and cost of living from region to region. These economic differences make it difficult to compare socioeconomic status (SES) of different regions. Since the data in the study shall come from one region of Tennessee, the variability in income and cost of living shall not interfere with the interpretation of SES. Students of low socioeconomic status are designated as economically disadvantaged (ED).

Index Variables shall apply to those various indicators toward traditional or reform instruction important to quantify through the teacher questionnaire.

College Academic Readiness shall refer to the expected success of high school students as they approach college. Tennessee, as part of their partnership with the College and Career Ready Policy Institute (CCRPI), a project funded through the Bill and Melinda Gates Foundation, set the goal of improving college academic readiness rates. The indicators established for college ready high school mathematics students were: a) scores of proficient or advanced on Algebra II end-of-course assessments, b) meeting the ACT college-readiness benchmark score, and c) attainment of post-secondary credit through dual enrollment, Advanced Placement exams, or College Level Examination Program (CLEP) exams or attainment of industry certification (Tennessee DOE, 2009). This research study will rely on indicator b) as the operational definition of college academic readiness in mathematics. Meeting college benchmarks on the ACT subtest is indicative of a high likelihood for college success in the entry level course (Camara, 2013).

Assumptions, Limitations, Scope and Delimitations

There are some assumed facts accepted as true by reform leaders and policy makers not yet verified:

1) Reform education will equalize education for all sectors of society.
2) Reform practices will improve high school student outcomes predictive of college readiness in mathematics.
3) Reform practices, more than traditional practices, will engage rural high school students in the learning of mathematics.

These three assumptions are embedded in the framework of current reform efforts. The proposed study may provide support for these assumptions in the rural learning context or outcomes of the study may indicate that traditional instructional practices are equally effective. Assumptions made by the researcher will coexist with the reform movement assumptions. An underlying assumption of the study pertains to measurement of college readiness. The American College Test (ACT) has consistently claimed to measure students' college academic readiness with specific scores linked to predictive success levels in college (ACT, college & career, 2014). Other tests, including state TCAP end of course (EOC) tests, SAT, and NAEP, also propose to measure college readiness. Neither

SAT nor NAEP are consistently administered across Tennessee high schools. The only state mandated tests in Tennessee high schools are the ACT sections on reading, science, English, and mathematics for all eleventh graders, TCAP for all elementary and middle school students, and EOC for high school students in the core academic courses in mathematics, English, social studies, and science (TN DOE, core curriculum, 2014). The proposed study assumes that the ACT is an accurate predictor of college math preparedness, as recognized by the state of Tennessee and the nation. The study, limited to one representative high school, does not necessarily lead to generalizations about other populations.

Assumptions Regarding Testing

Common Core states are preparing to implement CCSS reform assessments, selecting the Partnership for Assessment of Readiness for College and Careers (PARCC) or Smarter Balanced Assessment Consortium (SB) or a state designed assessment, with a variable time-frame for implementation at the high school level. Both PARCC and SB tests claim to measure college preparedness (PARCC, 2014; SB, 2014). Several Common Core states are currently planning to utilize the PARCC, about a dozen states and the District of Columbia have chosen SB, and other common core states, including Tennessee, have opted to design their own comparable tests. This may impede future comparison of outcomes between states using different assessments of college readiness.

Measurements of College Academic Readiness. The ACT is common to all states but not all states require every high school student to test using this metric for college academic readiness. Some states favor the Scholastic Achievement Test (SAT) for college entrance. Tennessee State Department of Education funds administration of the ACT during the regular school day to all high school eleventh graders in Tennessee, regardless of their college plans. Only eleven other states tested 100% of their students on ACT (ACT, State Services, 2014), making a slightly unfair comparison between the average Math ACT in Tennessee and states that test a smaller percentage of their students using the same test. Beginning in 2014, a total of thirteen states required 100% participation. ACT does propose to assess college academic readiness and the ACT group does provide benchmark indicators for freshman college success in mathematics as well as indicators for career success (ACT, College & Career, 2013). In 2013, only 29% of Tennessee students testing on ACT achieved the readiness levels indicated by ACT for mathematics while 44% of the nation met this benchmark score (ACT, State Services, 2014). In 2014, 30% of Tennessee students met the mathematics benchmark while 43% of the nation met the mathematics benchmark (ACT, College & Career, 2014). Tennessee received special ACT recognition for "unusual and impressive test gains" (ACT, August 2014) due to the unprecedented gains in all areas of the ACT. Though Tennessee scores still lag behind most of the nation, these recent improvements encourage educators, parents, and students toward future improvements in college academic preparedness. There may be underlying reasons causing rural students to exhibit less promise in mathematics. Research on school readiness of children from low-income families (Okado, Bierman, & Welsh, 2014) indicated that the demoralization of parents can negatively impact student success in school. Cultural sensitivity to disadvantaged children should also extend to their parents. Student outcomes are linked to parental involvement (Noel, Stark, Redford, National Center for Education Statistics, & American Institutes for, R., 2015). Educators hope to address these reasons for low achievement among rural students through improved effectiveness of instruction. The underlying assumption is that a test can accurately measure student college math readiness.

Potential Weaknesses of the Study

Potential weaknesses of the study are infidelity in reform practice implementation, potentially a small data collection due to lack of access, and expediency of the study. The underlying assumptions and inherent limitations described here are noteworthy but do not pose major threats to the integrity of the study. An examination of each potential weakness follows.

Limitations of Teacher Perception of Implementation. The infidelity in implementation of reform instructional practices and the accuracy assessing the degree of impact by the student's current teacher may be two short comings of the research. Efforts to obtain accurate profiles of teachers' instructional patterns will increase reliability of results. Teachers' own assessments of their instructional practices will be determined through repeated questionnaires. Limiting the research to one system of Tennessee and one rural high school will increase consistency within the context of the data collection but may decrease the sample size.

Limitations of Data Collection. Accuracy of the measurement of college academic readiness as measured by mathematics ACT scores may limit the research study. Eleventh graders in Tennessee are the target group tested on ACT each year. Their individual scores may improve as they advance into their senior year and develop more college readiness through an additional mathematics course. It will be necessary to limit the sample to a group of high school juniors in order to obtain a large consistent sampling of student scores. Not all seniors in any region of Tennessee participate in the ACT. Tennessee requires 100% of 11th graders to take the ACT during the spring of their junior year and administers the test during the school day to ensure optimal participation.

Scope and Delimitations

Limitations of the research study lie in data access and homogeneity of the data source. Restricting the data source to Tennessee increases the likelihood of homogeneity of data since the Tennessee teachers have all experienced the continuum of reform training with the transition into CCSS. Though implementation of teaching practices is monitored by administrators for teacher evaluative purposes, individual teachers employ the practices at different levels of reform. The degree of reform practices implemented will rely on teacher responses to questionnaires. The assumption is that every teacher will accurately assess their own instructional practices. Repeated questionnaires will increase accuracy of the teachers' responses.

Limitation of Current Teacher Impact. Another shortcoming is that the data will correlate only the current mathematics teacher's practices with his/her individual students' outcomes. The performance of a student may rely on the cumulative effect of his previous teachers, not only the current teacher. The history of other teachers' impact on the student's college math readiness cannot be quantified through this study. Though the current teacher may be using reform instructional practices, prior teachers may have influenced the student's achievement in mathematics and those prior teachers' practices may have been traditional, reform, or a combination of both. It is important to realize that this historical background does not allow for purity in the type of practices the student has experienced. However, it does assume that all students in the study have had similar experiences in their background and that the current teacher has the prevailing influence on current testing performance.

Bounds of the Study. The data collection will be restricted to one rural region of Tennessee demographically representative of rural situations across the state. All high schools in the state are subject to the same EOC in mathematics. The mathematics frameworks and standards for Tennessee and Common Core are available online (see Appendix A). All Tennessee teachers are subject to the same evaluative measures and accountable to both CCSS and EOC standards. The immediate bounds of the study may appear to be an isolated region of the state but in actuality this region may be a snapshot of the state's rural capacity for gains in mathematics education. The advantaged perspective of teachers as they utilize information about effective practices can be far reaching. The encouragement offered to high school students through improved success in mathematics can move them toward successful college academic experiences (Kessler & Snodgrass, 2014). Insights gained from the study at one rural high school may assist curriculum development and selection across the entire state.

Positive Social Change

Rural high school educators across the South may be informed by results of the study. The results may be applicable to other rural regions of the nation where effectiveness of instructional practices in the rural context can be improved with increased attention to rural anomalies. The results may be far reaching beyond the rural regions of the United States as global competitiveness may be enhanced if rural students in the nation can improve college academic readiness through increased use of effective practices. An increased preparedness may translate into better career opportunities for rural students who may further improve the economic situation of both their individual rural communities and the entire state and nation. Important points of the study are

- finding effective practices to motivate and engage high school mathematics students
- modification of practices to fit the rural contextual learning experience
- improved rural student outcomes for college readiness in mathematics

These contributing gains in the knowledge base will provide benefits to all three levels: local, state, and national.

Tennessee high school math teachers are in transition into reform practices and need information regarding best instructional approaches for improved student outcomes. Educators and students in rural Southern high schools stand to gain from research that correlates teacher instructional practices with student predictive success in college. The teaching and learning of mathematics in rural high schools are complex processes that produce variable results. STEM careers depend upon mathematical talent in the generation of students currently enrolled in public schools. Motivating reform practices to meet national standards is not the goal of this research. Rather, the goal is to illuminate effective practices toward improving education of rural students in mathematics so that rural communities, as well as the nation, may have available resources for progress. The untapped resource of mathematical talent in rural areas is critical to moving rural communities toward a better quality of local living and each rural community is vital to the welfare of the nation.

The Common Core State Standards (CCSS) emphasize application of concepts, reasoning and sense making, and critical thinking skills as opposed to memorization and algorithmic computation of traditional mathematics classes. Current teacher training encourages implementation of constructivist instruction that employs social interaction, reflective thinking, and verbalization of learning as critical skills that develop reasoning and sense making. Researchers Sears and Reagin (2013) indicated that collaborative problem solving may work well for some tasks while independent problem solving with minimal feedback works better for other tasks, dependent upon the level of complexity of the task. Rural learners have specific cultural characteristics that may impact their response to constructivist instructional strategies. Research data regarding the rural response to CCSS instruction and assessments need to be updated as CCSS become fully implemented in rural schools of the South. There were little or no current data to respond to the question regarding rural high schools' assessment of college academic readiness following reform instruction and this study intended to add to that knowledge base. The study had to consider innate rural barriers such as implementation of reform practices in rural areas that may have obstacles such as monetary constraints, availability of resources, teacher training, and relevancy of curriculum in the rural context. The obstacles were held constant since I confined the study to one sample school.

As a Race to the Top Award recipient, Tennessee began implementation of CCSS in elementary and middle public schools in 2009 and proceeded to expand into Tennessee public high schools with full implementation by 2014. Research using current practices of Tennessee's high school mathematics teachers and students can fill this gap and afford vital information regarding effective practices toward student outcomes. The RTTT state has already shown significant progress in the elementary mathematics following implementation of reform practices.

Chapters two and three of the dissertation offer a complete research background and a detailed description of the research study, respectively. Chapters four and five amplify the status, trends, immediate needs, and projected gains of Tennessee's students in high school mathematics by reporting and analyzing current data. A thorough examination of reform practices in Tennessee's rural schools is applicable to other rural areas of the nation as well as around the world. The study's findings enable an informed perspective of the needs of rural high school students of mathematics in the sample school with suggestive indications for improvements across other rural public schools where poverty and low math performance prevails.

The learning process for students in the rural sector of the nation is subject to several influential factors. Research into pedagogy suggests two primary factors are teacher knowledge and instructional practices. Research into rural anomalies suggests that poverty and the relational interaction between student and teacher are also influential factors. A renewed focus on relevancy of mathematics has led to reform mathematics instruction based on Piaget's cognitive development and Vygotsky's social constructivism. Recent research on brain activity of students transferring between multiple representations of mathematical concepts (Waisman, Leikin, Shaul, & Leikin, 2014) support the effectiveness of constructivist theory. Examination of effective teaching of mathematics in rural high schools is essential as schools strive to meet testing mandates and adjust to rigorous standards. Teacher interpretations of new strategies often lead to variable implementations. Rural student outcomes may rely on the cumulative effect of math teachers practicing instruction relevant in the rural context.

Improving the outcomes of the rural sector in mathematics is vital to the growth of rural communities and to the national economy dependent on an adequate supply of STEM trained students. Equity in learning opportunities for the rich untapped resource of rural mathematics students prompts research into effective practices in rural high school mathematics, the gate-keeper for STEM careers. An examination of existing research established a background for the study.

Chapter 2: Literature Review

Introduction

The problem of inequitable representation of rural and non-rural students in math related careers in the United States stems from the persistent performance gap in high school math. The purpose of this research study was to identify effective math instruction techniques for rural U.S. high school students preparing for college. Literature informing educators of theories, statistical records, and evidence of prior studies provided a multidimensional perspective. The literature review discusses three different literary contexts: educational theories linked to mathematics reform, artifacts from statistical reports and informative essays from experts in the field, and recent studies regarding classroom instruction and student outcomes. The current status of mathematics education in the United States is evidenced in all three contexts.

Three different venues of literature supported the research study: reputable statistical reports, expert educational forums, and scholarly, peer-reviewed journals. As educators rely on constructivist theory to transition into new standards and updated curriculum, leaders at all levels of implementation have observed, analyzed, and recommended a variety of actions intended to increase effective teaching and learning. Artifacts from the state and national levels lent perspective to the current conditions of mathematics education in the United States, specifically conditions in the Southern states. References to reform initiatives in mathematics include critical reflections on several quantitative and qualitative studies in grades K-12 in the United States as well as other nations. The results of various curriculum choices and testing mandates lent support to the proposed study. Research suggesting the characteristics of different learners refines the perspective of learners in the rural environment.

This review also presents findings from articles offering a close look at reform practices in secondary mathematics and a review of recent quantitative and qualitative studies in mathematics education for grades kindergarten through early college. Studies involving teacher and classroom influences on student achievement, with particular attention to rural and cultural influences on learning and student achievement, supported two essential components for the study:

- provide research demonstrating the importance of the connection between teacher practices and student outcomes, and
- underscore the need for the proposed study on rural high school mathematics education in regards to instructional practices and high school graduates' preparedness for college math.

Conclusive evidence and inconclusive evidence from the studies discussed below underscored the need for further study. This examination of prevalent theories in practice, existing conditions, and results from recent reform efforts provides a clear perspective of the potential for improvement in educational efforts in mathematics education in public high schools in rural America. The literature review is divided into four major sections: constructivist theory into practice, current status of math education, research studies linking instruction and learning, and rural anomalies impacting learners.

Literature Search Strategy

The research strategies used to obtain information regarding current reform initiative included searches of scholarly, peer-reviewed journals; research studies;

statistical reports; government artifacts; and various commentaries from leading educators and reform organizations. Information regarding mathematics education reform efforts was more abundant for elementary and middle school mathematics education than for high school. Targeting reforms in mathematics education resulted in identifying various studies. The initial key search terms were: reform education, mathematics reform, instructional practices, mathematics curriculum, best practices, and mathematics instruction. Some of these studies produced mutually consistent results, while others revealed conflicting findings. All of the examined studies urged continued research to more fully address questions regarding the relationship between teacher practices and improved student outcomes.

Restricting the search to the recent scholarly, peer-reviewed journals and books yielded relevant information regarding current trends and policies. Reflections from educational experts and statistical reports enhanced the historical and contextual perspective of current conditions in mathematics education. As research deepened, I identified new research terms to use in my literature search, including: college academic readiness, rural learners, reform instruction, rural outcomes, constructivism, project based instruction, inquiry based learning, and reform mathematics curriculum. Findings of vital statistics, relevant reports, new policies, and newly released research studies continued to impact this study as reform in mathematics education progressed during the research study. Searches primarily relied on Eric, ProQuest, and Educational Research Complete. As the researcher, I kept a continuous outlook for newly released documents during the course of the study. Updated statistics and commentaries from reputable educators and national education organizations further advanced the value and accuracy of the study.

Theories into Practice

Constructivist learning theories of Piaget (1928) and Vygotsky (1981) have shaped the ideals of reform practices that began in the early 1990's and progressed to current standards and applications (Draper, 2002, Yager, 1995). Current reform mathematics reveals a dependency on the sequential cognitive learning stages described by Piaget (1928) and the later theory of learning through social interactivity postulated by Vygotsky (1981). Both theorists stated that learning is motivated through engagement of the student in the learning process. The theory of developmental stages of the learner posited by Piaget (1928) supports notions found in more recent reform mathematics such as differentiation and curricular specialization for optimal engagement (Ojose, 2008; Piaget & Garcia, 1991; Powell & Kalina, 2009). Schonfield (2009) and Bennett (2010) agreed that integrating formative and summative assessments with interventions promotes student thinking. These systematic formative assessments serve as snapshots of weaknesses and strengths for student reflection and improvement (Areiza Restrepo, 2013).

Researchers have recommended several different tools and interventions to improve student performance. Newhouse and Tarricone (2014) endorsed the use of digital portfolios for summative assessments that build student efficacy. Hartman (2013) endorsed math coaching as an effective means of intervention, but opportunities for math coaching are scarce in rural high schools. Sarfo, Eshun, Elen, and Adentwi (2014) contrasted two different intervention designs in low performing high schools in Ghana to determine if traditional interventions in the classroom or problem-based inquiry interventions produced better outcomes. Both approaches brought conceptual understanding but the less traditional intervention design yielded deeper understanding of useful problem solving strategies. Implications of the various studies are that performance is connected to instruction and that high performance is a product of reform practices. These implications served as the impetus for the study.

Research studies focused on preparing all sectors of society for college have brought attention to the need for specific strategies to optimize student outcomes. Ratcliff and Bos (2013) used results from their study with racially and ethnically diverse middle and high school students to outline specific strategies effective in preparing students for college. Cai, Moyer, Wang, Hwang, Nie, and Garber's (2013) study of middle schoolers revealed that students receiving traditional curriculum and those receiving problem-based instruction were both challenged with problem-posing but student outcomes were slightly better for those accustomed to problem-based instruction. Kennedy and Odell (2014) similarly recommended that STEM teachers should focus on problem-based, project-based learning in a real world context to engage students. A high school study in Kentucky by Cramer and Mokher (2015) incorporated a college transition course for students not quite meeting state benchmarks for math due to the state's low ranking for college preparedness. The results were increased preparedness for college through the intervention program with 96% of rural students who participated in the math college transitional course meeting state benchmarks in math (Cramer & Mokher, 2015). These disparate studies by reputable educators and reform experts offer their reflections on how mathematics education is changing and that the curriculum is guiding teachers' approaches and vice-versa.

U.S. teachers' approaches to instruction are driving reform curricula in the United States (NCTM, 2010). Rothman, a senior fellow at the Alliance for Excellent Education and author of educational commentaries, described the readiness of United States high school graduates as ill-prepared for college or career (Rothman, 2012). Statistical data regarding the number of students entering technical careers and college who need remediation and the low retention rates of universities and community colleges support Rothman's premise (2012). These inadequacies have prompted increased attention toward improved standards and accountability intended to challenge students to higher achievement. Constructivist theorists maintain that students can and will aspire to higher achievement if stimulated through improved instructional practices (Piaget, 1928; Vygotsky, 1981). This theory has inspired curriculum reform and impelled increased teacher training. However, some contemporary education experts have warned that cognitive assessments that emphasize action and intervention compromise critical thinking (Embretson, 2010). Embretson (2010) explained that proficiency in numbers and number sense may be overshadowed by emphasis on critical thinking skills in the mathematics classroom. The commentary offered by Embretson paralleled that offered by Bennett (2010) and Hardre (2012), whose writings supported reform but pressed for student motivation and achievement in the process.

Lack of Conclusive Evidence. There was no consensus in the research literature on the best model for mathematics instruction to motivate student achievement. In fact, Harde (2012) and Howley (2009) agreed that specific attention is needed to improve teaching practices in rural situations. Both researchers encouraged educators to seek to understand the connection between learners and instruction. Howley (2013) advocated for equality across locales, claiming that the rural disadvantage could be used to advantage by leveraging local place value and community support. Howley further demonstrated the importance of rural math as an opportunity for unlimited growth. Hardre (2012) explained rural student engagement is further complicated by the inherent student differences in background, cultural values, and socioeconomics. Wavering (2011) explained how students respond to logical sequencing of learning, just as Piaget projected years earlier. Wavering expressed concern about how teachers would learn analysis of student discourse and how teachers would motivate deeper student understanding of conceptual science and mathematics. Wavering's essay offered a view of Piaget's thinking as a vehicle for science instruction. The information gained here indicated that the academic preparedness of rural students holds a strong connection to their rural culture. Implications for the study were devalued as consistency in teacher responses indicated little or no variability in the teachers' rural connectedness.

Constructivist Theories in Current Standards. Constructivist theories of learning support social interactivity, purposeful investigations, and collaborative reasoning toward solutions (Vygotsky, 1981). These same theories are evidenced in the framework of reform mathematics. The Common Core State Standards (CCSS) in secondary mathematics state specific learning expectations aligned with constructivist theory (Appendix B, Table B.1). Most state high school mathematics standards have constructivist theory embedded within the framework, as well. Vygotsky's (1981) emphasis on social constructivism is present in the National Council of Teachers of Mathematics (NCTM) projected standards (NCTM, 2000, 2010, 2013) where there has been consistent advocacy for project based learning, activity engagement, and student discourse.

The issue of equitable education for all students depends on culturally responsive instruction. Supporters of CCSS intended to promote equity in education for all students across the United States (Rothman, 2012). However, modern theorists described limitations of the benefits of uniform instructional pedagogy for all students (Bennett, 2010; Schonfield, 2009; Tutak, Bondy, & Adams, 2011). Rothman provided an essay that critically examined the lack of student readiness for college and suggested that CCSS would help with student preparation. Other experts (Tutak, Bondy, & Adams) focused on the particulars of instructional practices that motivate rural learners. Tutak joined with Bondy and Adams to address issues of critical pedagogy in critical mathematics education. Their essay (Tutak et al.) addressed classroom practices derived from John Dewey's (1938) experiential practices and Freire's liberatory problem solving practices (in Beckett, 2013). The authors pressed for culturally responsive teaching that empowers students toward equity for all people rather than for individual groups. The reform trend of cultural responsiveness is also important in teacher probes to motivate discourse and permit formative assessment (Keeley, 2014). The Tutak essay further recognized the National Council of Teachers of Mathematics as a leader of reform efforts in mathematics education traced back to their curriculum and evaluation standards (NCTM, 2010) and principles (NCTM, 2000, 2010).

The National Council of Teachers of Mathematics (NCTM, 2010) has continued to advocate for theories of mathematics education emphasizing cognitive and social constructivist approaches in instruction for decades and has taken a strong lead in promoting development of instructional strategies that incorporate critical thinking tasks, technology, and authentic learning activities (NCTM, 2000;,2010). These sources introduced the critical pedagogy of mathematics teaching that inspired the research questions regarding effective practices for improving student college readiness.

Current Conditions of Mathematics Education

National reports and statistics reflecting the current state of public education in the United States are available to the public. These artifacts contribute to the data driven endeavor of educational research. The National Center for Education Statistics (NCES) publishes an annual report card updating the status of schools and student performance for the nation and individual states. This report card, filled with statistical interpretations of the data collected, reflected the current condition of education in the United States for comparative purposes. Trends in student achievement from current statistical reports (NCES, 2013; Kera, Aud, Johnson, & National Center for Education Statistics, 2014; Hussar, Bailey, & NCES, 2014) suggested that high school mathematics education in the United States, particularly in the Southern states, is in need of reform. These reports provided current achievement test score data from the most recently completed school year and offered comparative data over several years. Though the scores were indicative of areas of need, the NCES report card only provided achievement data based on student scores and no conclusive suggestions for rectifying gaps.

Education expert Tienken (2008, 2010) and experts at the National Center of Educational Statistics (Brown et al, 2013) contributed their reflections on the current conditions of mathematics education in light of the statistical evidence. Tienken speculated about the implementation of the CCSS and their direct capacity for assisting with increasing the preparedness of the United States to compete academically with other nations. Tienken (2010) questioned the assumption that children in the United States are lagging behind those in other countries, as the rankings based on scores would indicate. Tienken (2010) pointed out disparities in testing among nations, the extreme issue of poverty in the United States, and the surprising performance of United States citizens as top science achievers in the world despite test scores that indicated mediocre performance in mathematics and science.

Research studies continue to update the importance of technology. One recent study (Jansen, *&* Petro van der Merwe, 2015) reported reform movements successfully adopting digital technologies into the instructional practice, enabling student-centered learning. Other experts in the field (Hanushek, Peterson, & Woessmann, 2012) assessed the performance of 4th and 8th graders in the United States in math, science, and reading based on a series of tests administered by international organizations. Hanushek, a senior fellow at the Hoover Institution of Stanford University, Peterson, director of the Harvard Program on Education Policy and Governance, and Woessmann, head of the Department of Human Capital and Innovation at the Ifo Institute at the University of Munich, offered their expertise as to why the United States was not showing clear global competitiveness. Their analysis reported that students in Latvia, Chile, and Brazil "improved at an annual rate over twice that of the United States" (Hanushek et al.). Also, their findings revealed that 11 other countries were advancing at twice the pace of the United States while the United States was not among the nine countries falling behind at the greatest pace. The commentary speculated that the failure of the United States to close the international test score gap hinged on unrealistic goal setting and the variation of productivity among the different states. They asserted that the strong gains in the Southern region may have been related to political efforts toward equalizing educational opportunity.

Governors from the southern states of Tennessee, North Carolina, Florida, Texas, and Arkansas have been involved in national leadership during the reform movement and have been diligent in efforts toward accountability to achieve equitable education for all student sectors. Research into the black-white achievement gap revealed little or no reduction in the student achievement gap since the No Child Left Behind reform efforts (Braun, Chapman, & Vezzu, 2010). Though poverty and minority status continue to plague student achievement, no research claims a solution to the problems inherent in rural communities. Most research concludes that poverty is the main obstacle to student achievement (Burney & Beilke, 2008) yet poverty is a much more complicated problem to address than other educational reforms.

The Center on Education Policy (CEP), an independent nonprofit organization funded and supported by the Bill and Melinda Gates Foundation as well as the George Gund Foundation, the Phi Delta Kappa International Foundation, and the National Center for Education Statistics, releases reports periodically that contribute key findings regarding implementation of the common core state standards. Their reports (Ballou, 2012; Hussar, Bailey, & National Center for Education Statistics, 2014; Kober & Rentmer, January 2011; September 2011; McIntosh, 2012; Rentmer & Kober, 2012; Trujillo & Renee, 2012) provided statistics regarding the states' progress with implementation strategies, professional development, and assessments and reviewed separate reports on education trends and impacts of reform initiatives. These reports supply statistical information and a national perspective of the states' response to reform efforts.

The National Governors Association (NGA), founded in 1908 as a bipartisan organization of all the nation's governors, also supplied summary reports that addressed issues in student accountability (NGA, 2010, 2012). One report (2012) explained alternatives to federal authority on development of accountability models measuring college academic readiness. The NGA faulted the federal accountability system evolving from the No Child Left Behind Act (NCLB) with unrealistic goals of 100 percent proficiency by 2014 and an unclear focus on how to prepare students. The report recommended a model for college or career readiness based on multiple performance measures, incentives for hardest to serve students, and realistic target goals (NGA, 2012).

Expert reflections (Good, 2010; Scott, 2011) on the role of federal involvement in education following the release of *A Nation at Risk* (1983). Good and Scott have commonalities in their separate essays. Both provided a historical perspective on the reform efforts focused on improving education for the purpose of globalization and economic competitiveness. Good's essay addressed comments from the particular members of the committee who authored *A Nation at Risk,* issued in 1983 and spawned an educational reform still in motion today. Good reported that the eclectic group of committee members had approached the compilation and writing of the report with keen attention to investigated details. Though intended for the executive officials, it was released as an open letter to the American public. Good's historical record regarding the report provided the political background essential to understanding current reform efforts toward improving mathematics and science instruction. Scott's essay provided an updated political perspective that addressed social justice as a critical component toward understanding and improving American education. Scott offered strong arguments against the for-profit companies forwarding their own selfish interests through educational channels. Both authors make connections between economic status and student achievement.

Scores on the National Assessment of Educational Progress (NAEP) tests broaden the usefulness of the nation's report card (National Center for Education Statistics, 2011) to allow educators and policy makers to focus on areas of student need rather than on competitive interests. The National Center for Educational Statistics Report (Aud, et al., 2013) on the condition of American education broadened the perspective of test scores to afford a positive approach toward reform in mathematics education as it focuses on employment trends across the nation, high percentages of children in poverty in particular regions, and unemployment rates. These statistics provided a clearer perspective of the challenges facing public education in the Southeastern region of the United States.

Educational Reform in Tennessee

The Tennessee State Collaborative on Reforming Education (SCORE, 2014; 2014-15) annual reports combine both statistical data on student testing with policy makers' commentary on the current status of education in Tennessee. The SCORE committee, composed mostly of interested business leaders and state department of education members, regularly conducts focus groups and round table discussions with educators and parents across the state to deepen their understanding of the status of reform. SCORE's cumulative report (2013-14), published online and also distributed in print in January of each year, provided statistical information and described the status of

Tennessee's schools compared to prior years and compared to other states across the nation. This report, guided by NAEP, Tennessee Comprehensive Assessment Program (TCAP) which translates into achievement tests for grades 3 through 8 and end of course (EOC) tests in core subjects in grades 9 through 11, and American College Test (ACT) data, and public input, celebrated successes in the state's current performance and offered steps for further improvements (SCORE, 2014). The authors of the report offered positive steps toward higher achievement, recognized significant 2013 gains in elementary mathematics and slight gains in secondary mathematics. The SCORE committee recommended these priority steps for Tennessee for 2013-14:

- Maintain high student expectations
- Implement PARCC assessments to measure student learning with CCSS
- Keep public fully informed of CCSS and aligned assessments
- Develop a solid foundation in literacy across all subjects

Priority steps for Tennessee proposed for 2014-15 were:

- Select and implement high quality assessments that are nationally benchmarked.
- Continue implementation of Tennessee State Standards with improvements.
- Elevate the teaching profession through encouraging high-quality candidates and supporting current teachers.
- Promote high-quality school leadership to meet local needs.

SCORE announced that progress reports will be issued throughout the year tracking what steps have been taken and how education partners can assist. Regular updates will bring into focus the areas where more support is needed (SCORE, 2015). One such update is that Tennessee, who initially chose to test math students using PARCC, has now passed legislature endorsing the state development of standards testing. The new testing, designated TN Ready, was slated for the 2015-2016 school year. Continued monitoring of progress and measurement of success will be advantageous to Tennessee educators and students as informed decisions are made in curriculum selection and implementation. As studies emerge in support of reform mathematics, leaders in math and science can make informed decisions and develop effective practices directed toward improving rural education (Lockmiller, Huggins, & Acker-Hocevar, 2012). Research directed to specific rural communities in Tennessee promise a unique view of rural needs.

Reform Mathematics

The United States Department of Education contributed an evaluative report (2008) on mathematics education as a follow-up from the *Nation at Risk* (1985) concluding that mathematics instruction should be varied and not completely student-centered or entirely teacher-centered. This information may serve the reform efforts well during the transition into reform mathematics instruction. It is important to deliberately teach to the CCSS if students are to improve outcomes (Phillips & Wong, 2012). Adopting reform standards does little to improve education without effective teacher implementation.

Standards and Measures. As states strengthen their existing standards or adopt CCSS, teachers may transform instructional practices to meet increased student expectations. A report comparing each individual state’s standards and national standards (Carmichael, Martino, Porter-Magee, & Wilson, 2010) assessed Tennessee standards in high school mathematics as inferior to the CCSS. Tennessee's over-all score of C in high school mathematics standards reflected a mediocre set of standards lacking in clarity and specificity, as well as in content and rigor. This report concluded that the CCSS are more ambitious and challenging than state standards, though, reluctance to adopt the CCSS prevails due to persistent beliefs that the federal control of state education is increased through CCSS.

Overview of Reform Education in Secondary Mathematics. A historical documentation of educational reform efforts spanning 50 years (Kessinger, 2011) reviewed seven important federal government actions addressing educational reform in chronological order:

1) National Defense Education Act (NDEA) of 1958

2) Elementary and Secondary Education Act (ESEA) of 1965

3) The National Assessment of Educational Progress (NAEP)

4) *A Nation at Risk*

5) America 2000

6) Goals 2000

7) Elementary and Secondary Education Act of 2001 (No Child Left Behind, NCLB)

These seven historical acts by the federal government toward improving equity in education have tightened the federal hold over education with greater accountability of teachers to maintain high standards and of students to reach higher performance expectations (Kessinger). This document provided an extensive review of each initiative and how the progressive reforms pressed for equity in education. Important questions raised by the documentary concern the focus of reform efforts. Kessinger asserted that curriculum and instructional changes dedicated to sustainable, improved student outcomes ae a better focus than control issues or testing outcomes and assured readers that accountability measures will continue to include test results with a clear focus on learning and preparedness of both teachers and students.

The National Council of Teachers of Mathematics (NCTM) promoted reform in mathematics instruction through their *Principles and Standards* (NCTM, 1984; 2000, 2014). The National Governors Association Center for Best Practices (NGA, 2010) also advocated change and close attention to rigor, relevance, and problem solving activities. Both organizations, highly recognized for their bold steps toward reform, have precipitated a data-driven approach to measuring gains precipitated by reform efforts. A significant increase in the projected earnings for students who take math intensive subjects implies that an altered curriculum differentiated to meet the needs of more students may expand college access and increase the number of STEM prepared students. Reform experts Vogler and Burton (2010) and Vigdor (2013) contributed reports on trends that reflect curriculum reforms for increasing the rigor of mathematics courses. Vigdor cautioned that reform may not improve the science, technology, engineering, and mathematics (STEM) career supply unless changes in instructional practices allow equitable access to challenging mathematics courses. Harwell (2013) attributed the rigor of the high school math curricula to math course selection in college. The Vigdor (2013) study exposed trends of a decline in enrollment in mathematics intensive courses leading to STEM careers from 1944 to 2007. This serious movement away from higher level mathematics classes does little to improve the status of low-performing students.

Recent statistics in a study in Tennessee (University of TN, 2011) revealed a shortage in the top four STEM path with predictions for an increased gap in the supply and demand. Since mathematics capability is considered a key determinant of productivity, mathematics scores on the NAEP and PISA tests in the United States are important gauges regarding the projected earnings from those students as they become adults. Many states have state exit exams with required performance levels determining high school graduation. Some states, such as Tennessee (TN DOE, 2014), require end-of-course tests but do not designate minimum scores for graduation. Other states have achievement tests or are in transition toward standards-based tests. Some states use evaluative tests of their own design, some use commercially prepared tests (McIntosh, 2012).

The increased importance of testing toward obtaining data has been a factor in curriculum selection, teacher practices, and student outcome. Operationalizing classroom standards-based instruction is part of the Bill and Melinda Gates' Mathematics Design Collaborative (MDC) and also motivates the push toward adjustments in mathematics instruction (Duffy, Park, & RFA, 2012). The brief provided by Duffy and Park (2012) detailed mathematics instructional changes from the traditional to standards-based instruction. The fundamental differences included constant facilitation and assessment of student learning.

Reform practices encourage both formative and summative assessments as opposed to only summative (Duffy & Park, 2012). Traditional practices of lecture, practice, check homework, review, and test are no longer considered effective (Duffy & Park). Adjustment of teacher practices may better equip students to think, conceptualize the learning, and make application to new situations (Duffy & Park). All of these skills (thinking, conceptualizing, and applying) are basic components of the MDC. Though no Tennessee mathematics teachers received specific MDC training, there were similar instructional approaches advocated through CCSS training sessions across the state. The new approaches include formative and summative assessments and constant facilitation of learning through collaborative activities, ideas promoted through Vygotskian social constructivism.

Eacott and Holmes (2010) described reform efforts in mathematics education as essential changes in curriculum and instruction and Vigdor (2013) provided an example of efforts in North Carolina to open rigorous mathematics to 7th and 8th graders. Eacott and Holmes explained how the decline in enrollment in higher mathematics at the higher education level had become a trend that may be difficult to reverse.

The decline in interest in mathematics does little to alleviate the shortage of STEM careerists in the increasingly digital age. Eacott and Holmes (2010) discussed recent reform efforts across Australia and across the globe and pressed for mathematics reform through a reform in mathematics leadership literacy in all contexts: cultural, social, political, historical, and futuristic. Their report called for research to target effective practices to enable a broader attraction to the field of mathematics. Vigdor (2013) recommended gearing the course rigor to the individual student capacity rather than pressing for early acceleration into higher mathematics. The sensitivity toward differentiation appears to be a missing focus of many reform mathematics initiatives. Vigdor’s essay further documented the “math slide” from 1944 to 2007 revealing that Americans are studying mathematics dramatically less today than in the past. The supply for STEM graduates is in dire need of replenishment and the responsibility lies with mathematics leadership.

Political Aspect of Achievement. Comparisons across countries in the NAEP performance of 4th and 8th graders from 1995 to 2009 indicated that the United States is in the middle of those making gains (Hanushek, Peterson, & Woessmann, 2012). Their collaborative report on international and state trends in test scores addressed the political aspect of keeping pace with other countries. State test score gains vary dramatically, with five of the top ten fastest improving states in the South where governors have been pressing for valiant efforts toward educational improvements. Tennessee, a first-round recipient of the Race to the Top (RTTT) federal funding is an example of one of the Southern states where improved NAEP performance in 4th and 8th grade mathematics followed intensive reform efforts (TN DOE, 2013).

A case study in a mid-western high school by Buckley (2010) involved a curriculum reform effort attempting to remedy inequity in mathematics education. Buckley’s results revealed some critical reform steps toward modifying algebra and geometry courses to encourage enrollment by students of color and low socioeconomic status. Reform efforts without continuous monitoring and deliberate, well-defined objectives appeared to be unsuccessful in encouraging underrepresented sectors into STEM. Recommendations for a rigorous and narrowed curriculum with substantial administrative support were echoed by results from the rural systemic initiatives funded by the National Science Foundation (NSF) in the several Rural Systemic Initiatives (RSI’s) described by Harmon and Smith (2012). The Harmon and Smith report, prepared by Edvantia, a corporation involved with research and development of knowledge, resources, and professional services for education, highlighted nine of the 30 models of change funded by the National Science Foundation. The Harmon and Smith report summarized the rural circumstances prevalent in the models, explained lessons learned, and recommended policy actions to efficiently and effectively promote positive system changes. A study by Buckley (2010), which will appear later in the review of quantitative studies, also recommended a holistic approach.

Recommendations for Redesign of Mathematics Curriculum. Redesigning the mathematics curriculum (Buckley, 2010; Nomme, 2014), strong leadership and dedicated teacher development (Harmon & Smith, 2012), and improved pedagogical content knowledge including use of technology (Guerrero, 2010), are collective evidence that these steps contribute toward successful efforts in mathematics education reform. Guerrero, an assistant professor of mathematics education at Northern Arizona University, combined her expertise in web technology with her knowledge of mathematics instruction to develop a pedagogy of change in the mathematics classroom. These individual efforts (Buckley; Harmon & Smith; Guerrero) indicated rural student success is possible, given supportive leadership, training, and tools. The effectiveness of increased rigor in high school for college preparation was further substantiated by research in Texas (Alford, Rudolph, Olson-Beal, & Hill, 2014). The importance of the teacher as a key component in every reform effort is assumed in every study. Deliberate attention to the instructional practices of successful mathematics teachers is helpful in development of best practices for rural student learning. This research further motivated the study to connect reform efforts to student outcomes and college preparedness.

Findings from Research Studies

Most of the research studies were quantitative in nature with studies found on reform practices and results more often with grades kindergarten through 8th grade than with high school students. Fewer studies were found on secondary level mathematics reform efforts. Those studies addressing the various influences on student outcomes are organized by each particular influence: curriculum, teacher instructional practices, student perception of competency, and rural contextual anomalies including prevalent low socioeconomics.

Curricular Influences on Student Outcomes

Marshall and Sorto (2012) completed a study correlating different forms of teacher mathematics knowledge and student achievement on rural Guatemalan primary students to determine teacher effect. Their results, also based on observational data, suggested specific mechanisms by which effective teachers can make substantial impacts on student learning, even in extremely poor contexts. Student scores tended to be lower in schools where more time was spent copying and solving problems individually. Teacher mathematics knowledge indicators had almost no correlation with the observed pedagogical choices of the teacher in primary situations (Marshall & Sorto). The authors drew no parallels to high school practices.

A quantitative study in Texas high schools based on data from 2003-2006 by Vega and Travis (2011) purported that it is difficult to obtain sufficient evidence to claim any connection between reform mathematics curriculum and student outcomes. The Texas Assessment of Knowledge and Skills (TAKS) is administered state-wide to all Texas high school students in ninth, tenth, and eleventh grades. Student scores on TAKS did not indicate any significant difference on student math understanding related to the reform curriculum employed in the classroom. However, the data suggested that some populations benefited from traditional instruction. Two subgroups that showed benefits of the reform curriculum instruction were ninth graders who were low SES or LEP and eleventh graders who were African American ethnicity. These two subgroups outperformed others taught traditionally. The researchers (Vega & Travis) expressed uncertainty about the fidelity of reform or traditional practices due to nonresponse on the teacher questionnaires. The data base of 27,000 student scores from reform classes and 25,500 student scores from traditional classes used in the data analysis provided a wide base of evidence but failed to generate a strong relationship between instructional practices and student outcomes.

Another quantitative study by Middleton, Leavy, and Lender (2013) investigated the relationship among critical motivational variables and the mathematics achievement of middle grade students engaged in the reform-oriented curriculum *Math in Context*. This study, involving more than 325 middle school students in a large Midwestern school district, spanned two years and employed the reform curriculum *Math in Context*, and data from the Iowa Test of Basic Skills along with a district administered algebra aptitude examination. The results of the study suggested that principles of curriculum design that maximize student motivation to learn mathematics at the middle school level can be fostered by reform-oriented instruction. The researchers (Middleton, Leavy, & Leader) concluded that achievement is dependent on other cognitive factors such as prior achievement and situational variables including high-quality content and teaching expertise. Their study suggested that logical, consistent, and energizing experiences build a productive environment to engage students in mathematics learning so that achievement progressively follows. The research team used a self-designed instrument to measure students' motivational attitudes toward mathematics at the beginning of the study and again after two years into the program. Repeated measures of ANOVA indicated a significant difference in student motivation across the two-year time frame. One-week site visits enabled the research team to include observational data into their analysis and allowed for substantiation of the motivational efforts. Researchers concluded that development of positive attitudes toward content may rely on instructional strategies in middle school mathematics classrooms.

Grady, Watkins, and Montalvo (2012) also completed a rural middle school study spanning two years that focused on the effects of the reform curriculum of *Mountain Math,* traditional curriculum, and total activity based constructivist curriculum. Grady serves as an Illinois high school principal and both Watkins and Montalvo are professors of education leadership at Western Illinois University. Like the Middleton (2013) study, this quantitative study (Grady et al.) relied on scores from the Illinois Standards Achievement Test. A two-way ANOVA was used to analyze any differences among scale scores using two years of data. The authors concluded that there were no significant differences with the comparison groups of students and that a more traditional approach used along with other reform methods may be as good as the *Everyday Math* curriculum in rural settings in grades K through six. However, the test score results at the rural middle school level of algebra (Grady et al.) showed a significant difference for those students using the constructivist approach over those using the more traditional constructivist instruction with an average of 3.9 points higher score on the Texas

Assessment of Academic Skills Math Test. Authors recommended a blended approach of traditional instruction in conjunction with reform strategies for optimal effectiveness. Other researchers (Tabor & Minch, 2013) concurred with the effectiveness of the blended approach of digital technology and traditional instruction.

A study in an urban school district by Jong, Pedulla, Reagan, Salomon-Fernandez, and Cochran-Smith (2010) examined classroom practices of beginning elementary mathematics teachers in relation to their students' learning. Researchers used teacher self-ratings on the Reformed Teaching Observation Protocol (RTOP) designed by the Evaluation Facilitation Group of the Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT). The results of the study on 22 beginning mathematics teachers indicated reformed teaching is positively and significantly related to elementary pupils' mathematics learning. The more reform practices used, the higher the students in the study performed on the state mathematics tests. The strong correlation between teachers' instructional practices and student outcomes indicated that the elementary students' performance was closely related to their classroom experiences. The researchers (Jong et al.) further concluded that both teacher content propositional knowledge and content procedural knowledge, as well as classroom culture developed by student-teacher relationships, significantly impact student performance. The data in their study yielded correlation values for R that were all higher than 0.5 for these factors (Jong et al.). This study contributed that teacher actions in urban settings are particularly important to student performance. Although this study had an urban setting and the current study is focused on the rural setting, the RTOP evaluative tool was useful in the selection of reform practices. The teacher questionnaire provided items for teachers' self-assessment of their own reform practices.

Researchers Barlow, Frick, Barker, and Phelps (2014) indicated that teachers often classify themselves as reform-oriented, when their practices indicate otherwise. To avoid any self-classification, the questionnaire items were not designated as reform or traditional, the response order varied to yield no pattern to reform orientation, and a variety of items were included. The tool needed modification since the reform practices for secondary vary somewhat from those practices employed at the elementary level. In addition, allowances for cultural sensitivity and place-based values for the rural situation, important to optimal educational success (Bartholomaeus, 2013) were essential considerations in the current study. More discussion on this will follow in chapter three as the methodology for the study is clearly defined.

An additional qualitative case study by Obara and Sloan (2010) reported the experiences of three 5th grade teachers and their math coach as they worked with new instructional materials during the implementation of a new state-mandated standards-based curriculum. The setting in the Georgia middle school, where 80% of the students were low SES and only 21% were white, revealed the importance of a mathematics coach to assist teachers during the transition into reform curriculum. This study drew attention to the prevalence of low SES students in rural schools. Also, researchers highlighted limited teacher access to necessary supportive reform resources and training in the rural setting. The study indicated that the hiring of math coaches had transpired due to inadequate teacher resources, few workshops, insufficient training, and no state-approved textbooks to support the new curriculum. Although teachers indicated they had revamped their instructional mode, data collected by the researcher indicated relatively little change in instruction from the traditional practices of before. The study concluded that teachers need time and supportive resources to properly transition from traditional to reform curriculum. Data drawn from audio-recorded interviews, video-recorded classroom observations, field notes, student work, and teachers' materials led to conclusions regarding teacher perception of the transition from traditional to reform curriculum. This conclusion heightens the awareness of the proposed study to focus on whether teacher practices are limited by insufficient time and lack of supportive resources. It is also important to keep in mind the resourcefulness of rural educators who make the most of their community resources to provide opportunities to their students (Franklin, 2012).

A contributing study in rural Canada (Li, Moorman, & Dyjur, 2010) reported significant boosts to rural student engagement through videoconferencing, e-mentoring, and inquiry-based learning supported by technology. Rural isolation need not translate as distant from all resources in this technology-driven reform era.

Teacher Influences on Student Outcomes

All research studies consistently agreed that the single most important influence on a learner's achievement was the teacher. The teacher factors recognized as vital were teacher content knowledge and interactivity with students. A study of African American youth from rural, urban, and suburban settings by Jones, Irvin, & Kibe (2012) and a case study of teachers by Gresalfi, Barnes, and Cross (2012) concurred with the synthesis of fifteen years of research on rural secondary students' school related motivation (Hardre, 2012) that rural people tend to emphasize relationships and connections with others. Hardre's research on rural secondary students concluded that teachers need to have motivational skills and understand if and why students are disengaged. The researcher explained that rural students, in particular, need teachers' support and competency building. Hardre concluded that the teacher-student relationship is strategic to the achievement of rural students in high school mathematics.

Research supported that social factors can change academic self-concept and impact motivation toward learning. The complicated challenge of motivating rural students often leaves teachers lacking effective motivational strategies (Hardre & Hennessey, 2013). The multiplicity of influential factors impacting student achievement clouds the picture of the proposed study which intends to focus specifically on instructional practices and test scores indicating college academic readiness for rural students. The intentional focus on the classroom teacher may reveal behavior patterns which correlate with rural student preparedness. The social factors investigated by Hardre or Jones, Irvin, and Kibe may provide insights into essential teacher practices.

Another social factor is the engagement of parents toward encouraging college aspirations. Financial support, guidance, recruitment and enrollment issues depend largely on parental involvement, particularly with rural students (Chankseliani, 2013). The effects of parental engagement in planning for college are critical to student college readiness (Dewey & Mitchell, 2014; Leonard, 2013).

Gresalfi, Barnes, and Cross (2012) conducted a case study of two upper elementary and middle school teachers using project-based learning with the same curriculum. The results of the case study indicated that students engage in project learning according to how teachers frame the opportunity for students to engage and learn (Gresalfi et al, 2012). Jones, Irvin, and Kibe (2012), in their study of 1049 African

American youth, conducted Chi-squared difference tests to determine whether the model fit varied among the three geographic settings but found little difference according to geographic setting. However, the researchers (Jones et al) admitted that the small sample of only 123 rural students may have marginalized their conclusions regarding the rural models. Results from their ANOVA analysis revealed:

- No difference in math performance between male and female African Americans
- No difference in SES among African American students in rural, suburban, and urban settings
- Significant differences among rural students for different genders' math self-concept, with females having a lower academic self-concept

Jones, Irvin, and Kibe (2012) concluded that the social variables may explain the low-math confidence of females in their rural context as they rely on peer approval and teacher nurturing. The small number of peers and interactive adults in remote rural settings may intensify the value placed on interpersonal relationships (Jones, Irvin, & Kibe). The study examined how students' perceptions of how their peers viewed their own academic self-concept and how their peers reacted to the students' academic performance. Jones, Irvin, and Kibe (2012) focused on whether or not peers had any influence on the academic performance of their friends and whether or not this difference was the same for African American students in rural, urban, and suburban settings. The study indicated that perception of math academics of peers influenced math self-concept, which in turn, influenced academic performance of students. Jones, Irvin, and Kibe used a chi-squared difference test to determine if the perception of peers' academic performance influenced students' math self-concept. The study indicated that social factors do influence academic self-concept and performance. However, Jones, Irvin, and Kibe (2012) acknowledged that their study failed to consider pertinent social variables such as the role of teachers or intra-community relationships which may be influential factors in the self-concept and performance of African American students in different geographic settings. The authors suggested these factors may be more influential in rural settings than in non-rural settings due to the close-knit communities in rural regions.

Different aspects of traditional and constructivist instruction allow for variable amounts of teacher-student interaction and may be related to the teacher's deliberate outreach. A study in Sweden by Oltenau and Holmqvist (2012) involved two teachers and 45 upper secondary students and focused specifically on the instruction of second-degree equations. E-mentoring and video-conferencing facilitated inquiry based learning by permitting students to interact digitally with professionals in the field while the students were confined to the classroom. This interaction increased student engagement by providing an appreciation for the utility of mathematics and first-hand understanding for future career potentialities (Olteanu & Holmqvist). Researchers explained that inquiry based learning environment (IBLE) is a reform strategy making mathematics meaningful and desirable to students while improving their college academic readiness. The study, demonstrating specific cognitive learning through use of digital media, extended the relational need to a contemporary level through use of tools unavailable with traditional instruction. Researchers concluded that digital interaction, a vivid component of IBLE, was an effective extension of the classroom experience for increasing student engagement.

A quantitative study by Akyuz and Berberoglu (2010) on teacher and student relationships and their effect on student achievement involving middle school students showed that academic performance is linked to a student's feelings of close ties with the teacher. The relation of mathematics teacher and classroom characteristics to 13-year-old students' achievement in TIMSS-R data across ten countries, rendered that the measure of home educational resources was the only significant variable impacting student math achievement on TIMSS that was common to all countries. The extensive study involved 1642 classrooms that encompassed 38,109 student scores in ten countries: Belgium, Czech Republic, Cyprus, Hungary, Italy, Lithuania, Netherlands, Slovak Republic, Slovenia, and Turkey. The investigation into the relation of the mathematics teacher and classroom characteristics to students' mathematics achievement relied on student TIMSS scores and classroom practices. The teacher characteristics were teacher gender, experience, and level of education. The index variables measuring instructional practices emphasized allocation of class time, facilitation of student reasoning and problem solving, homework, use of calculators, and class size. The textbook use had positive effects in developing countries but no effect in more developed countries. Belgium, a successful TIMSS country, revealed significant positive effects of lecture style and guided practice. The contemporary approach involving guided practice and independent group activity showed positive impact on student achievement in Belgium but negative impact in the lower performing country of the Czech Republic (Akyuz & Berberoglu, 2010). Researchers concluded that these inconsistent results among nations may indicate that different groups of students have different needs requiring diversity in teaching methodologies for prime student outcomes. According to the study, quiet classrooms with average size of twenty-two students yielded higher achievement in mathematics. This study (Akyuz & Berberoglu) suggested diversity among learners may be due to environmental factors.

A study regarding teacher quality and instructional practices compared student achievement on TIMSS across two countries. This quantitative study by Dodeen, Abdelfattah, Shumrani, and Abu Hilal (2012) compared teachers from Saudi and Taiwanese with regard to teacher preparation, professional development and their respective 8th grade students' TIMSS scores. The researchers (Dodeen et al.) selected two countries whose student scores ranked at the extremes on the TIMSS achievement scale to assess quality and practices differences based on questionnaire results. Results indicated that teachers need to be prepared to teach all mathematics topics in 8th grade for optimal student achievement and that positive support from parents, as well as improved professional development, are helpful in improving student outcomes. The results of the study reinforced the positive impact between teacher quality and student performance, regardless of the diverse performance history of students from the different countries.

Limitations of Teacher Instruction. An ecological case study by Gresalfi, Barnes, and Cross (2012) on two middle school teachers addressed the limitations of learning opportunities precipitated by reform classroom practices. This study analyzed data collected through observation of teacher and student interactions and survey responses coded to analyze relationships. The two teachers' instruction of a problem based learning unit using different engagement strategies resulted in different achievement by students. The research suggested that teachers who provide specific information and clear expectations appear to increase student engagement (Gresalfi et al.). The connection between this study and the proposed study is that teacher practices that generate student engagement may precipitate improved student outcomes.

A case study by Battey (2013), funded by the National Science Foundation, investigated the effects of reform-minded pedagogical instruction on two African-American and 23 Latino students in a southwest urban 4th grade classroom. The research focused on the effects of positive relational interactions between the teachers and students as related to improvement in student outcomes. The study suggested that the teacher instructional practices of formative assessment, guided activities with constructive feedback, and cultural sensitivity may be vital for student learning in a rural high school mathematics classroom, as well as in the urban 4th grade classroom. Students of color and those in poverty may respond to positive relational interactions with improved outcomes.

A qualitative research study by Huang and Normandia (2009) focused on students' perceptions of communicating mathematically in response to demand for reform and revised curriculum standards. This ethnographic case study, partially supported by a Grant-in-Aid-for-Creativity Award from Monmouth University, included data collected from class observations, audio taping, course plans, textbook content, student work, and student interviews from 25 suburban private high school precalculus students from mid-high socioeconomic backgrounds. The results of the study indicated that effective teacher practices incorporate the "why" in order to promote student discourse and fortify procedural steps in mathematics. The research linked the reform practice of increased student discourse to increased student understanding of mathematics.

One study by Kim (2010) incorporating both qualitative and quantitative data described a method of improving mathematics achievement of academically deficient seventh grade students with disruptive behavior in an urban school environment. Data collected from class observation, as well as teacher and student interviews used descriptive statistics and multivariate analysis of variance (MANOVA) with repeated measures to evaluate effects of a Mathematics Enhancement Group (MEG), a pull-out program targeting disruptive low-achievers in mathematics. The individual attention to students through student-teacher interactions, response to student questions, re-teaching, and student discourse were components of the study that allowed the researcher to conclude their effectiveness for improving student outcomes. The researcher concluded that small class size and individualized study time were major factors impacting the ability of underprivileged students to perform on standardized mathematics tests. Research into specific problem solving instructional strategies reiterate the importance of teacher alertness to individual student struggles (Booth, Barbieri, Eyer, & Paré-Blagoev, 2014). These factors are also influential with rural students at the secondary mathematics level as the research study indicated.

Socioeconomic Influences on Student Outcomes

The impact of socioeconomics on student testing was the focus of the quantitative research using 8th grade reading data from a large South-central Florida County public school district. It is notable that 66% of the students were from Title 1 schools and only 33% of the students passed the Florida Comprehensive Achievement

Test (FCAT). This data has several possible interpretations regarding students' socioeconomic status. Researchers observed that the gap in performance between low SES students and higher SES students may be dependent on environmental factors, originating and perpetuated by home-life or specific classroom factors, where teacher interventions and motivational engagement might raise expectations of achievement levels. The study offered no conclusive evidence of what factors influenced student performance except that low SES students are more likely to score lower than higher SES students on high-stakes testing.

A similar study in northern California by Park, Holloway, Arendtsz, Bempechat, and Li (2012) compared achievement test scores from 94 low SES 9th graders of diverse ethnicities. Data from two high schools ranking in the second lowest decile of California high schools on the state-wide achievement test included questionnaire responses from volunteer students. The questionnaires measured perception of competency and self-determination indicating emotional engagement in school. The research team used a chi-square test to determine predictors of emotional engagement as demonstrated through five hierarchical linear models. Conclusions from the study were consistent with other research studies in that students are more engaged when learning experiences included opportunities for student autonomy, growth in competency, and when the content is relevant to the students' realm of experience. The evidence regarding the importance of the teacher toward optimizing student achievement reiterates previous research findings attributing student learning to teacher relational quality. Teachers who promote feelings of student competency and support throughout the learning experience are more likely to generate higher levels of achievement. The study rendered three psychological predictors of emotional engagement within specific learning contexts: a) opportunity for student autonomy, b) feelings of competency, and c) relevance of content. The conclusions of the study were that teachers learning tasks approached with a) strong presence of teacher support, b) student feelings of competency, and c) a measure of student autonomy in the task increased emotional engagement and enhanced the learning outcomes. It is notable that this study, conducted at the ninth grade level, failed to project a means for attainment of the three criteria in low performing students. The researchers suggested that teachers who plan to successfully employ the three psychological predictors of engagement may expect to utilize constructive instructional strategies focused on student autonomy, competency, and relatedness but provided no specific strategies. They concluded that traditional lecture and review may not provide adequate focus on all three predictors of student emotional engagement. The researchers suggested that future research should examine how teachers motivate students toward emotional engagement prior to assessing student outcomes. The study further suggested that, since motivation correlates with student engagement then different instructional practices may correlate with different student outcomes. The results reported with low SES California ninth graders (Park et al.) may indicate that students' emotional engagement and perception of competency of other low socioeconomic learners is related to the teacher's instructional practices.

Influence of Instructional Practices on Student Outcomes

An extensive quantitative study by Vogler and Burton (2010) addressed instructional practices during a time of high-stakes testing in 55 Mississippi and 53 Tennessee school systems. The study investigated teacher selection of practices and tools and the influences on their selection. Teachers from both states reported using a combination of reform and traditional practices. They agreed that testing influenced time, activities, and selection of resources and classroom instructional tools. The study relied on teacher surveys and employed a nonexperimental design which did not allow for definitive conclusions regarding specific instructional practices and whether the practices were presented more traditionally or with more reform emphasis. The researchers recommended further research to study how instructional practices influence student outcomes. The timing of the Vogler and Burton (2010) study was early in the transition into reform practices when all high schools in Tennessee had not yet completed teacher training in standards-based reform practices. The transition into CCSS has driven core training across the state and a reform of practices has begun to reshape the instruction in high schools across the state. In 2015, Governor Haslam led a movement to replace CCSS with a Tennessee State Standards expected to reflect some CCSS characteristics with some state modifications.

A quantitative study in Sweden by Olteanu and Holmqvist (2012) compared two female teachers' instructional practices for teaching the solving of quadratic equations and their respective student outcomes on identical tests. The study (Olteanu & Holmqvist) included 45 students in an upper secondary school in Sweden. Important outcomes of the study were that the manner in which a teacher structured the learning experience influenced the way in which students' attention was focused on the critical aspects of learning. Two specific implications were: a theoretical-based design of instruction could be used to increase student outcomes, and teachers can effectively assess what it takes for students to gain mathematical knowledge. The first implication directly focuses on the proposed study linking instructional practices with student outcomes. The second implication supports teacher assessment of student needs. Both notions encourage teacher autonomy to assess student needs and employ appropriate practices to achieve optimal student outcomes. These implications had a distinct bearing on the framework of the current study intending to link student needs with outcomes.

A quantitative study by Tsai, Shen, and Tsai (2011) investigated the development of a blended learning (BL) design using face-to-face teacher instruction along with online instruction. The design incorporated an instructional paradigm that learning is optimized with a blend of teacher directed and self-regulated learning. The study addressed the same mathematical content, pretested and post-tested three groups of students over a time period of sixteen weeks of study, and targeted second year vocational college students from various major fields of study. About 90% of the participants were graduates from high schools in Taiwan. The three different groups received different instructional formats: strictly face-to-face instruction, exclusively online instruction, and the BL or blended group. The BL group received a combination of both online and face-to-face instruction. The relationship between methodology and student outcomes was most noticeable with the BL group of students who outscored each of the other two groups who received exclusively face-to-face instruction or exclusively online instruction. Altogether 112 students participated by enrolling in one of three different sections of the "Database Management System" semester-long course. The post test was the exam used for the certification of Microsoft Access that was administered at the end of the course. The authors of the study suggested that teachers might leverage technology toward improved student outcomes by developing their own proficiency and facilitating student learning experiences purposefully

Student Perception of Success. College students also maintain a link between perception of mathematics ability and performance according to a study that examined the self-efficacy of students in mathematics when they are in an underdog position (Davis, 2011). This quantitative study of 165 college students treated some students with information that they were less competent than a competing team with SAT scores that far surpassed their own scores. Another group at the same Southeastern United States liberal arts university was led to believe that they were “top-dogs” against the competing university. Students’ perceptions of their feelings of helplessness and math self-efficacy diminished when they were in the “underdog” group according to independent t-test sampling based on student surveys. The link between implicit theories of mathematics ability and self-perceptions is especially powerful in situations of ego-threat such as being in an underdog situation. Testing may intimidate students and poor past performance may tend to decrease self-efficacy and lessen the performance for some students. The applications from this study are: 1) for teachers to become mediators who provide opportunities for success and thus reduce feelings of helplessness prior to testing, and 2) for rural students to overcome their perception as the underdog. Davis concluded that classroom practices building student confidence may be beneficial to those students whose past performance predicates low self-efficacy in mathematics ability.

A similar study regarding self-perception of ability by Crosnoe (2009) investigated the effects of socioeconomic desegregation on 1,119 ninth, tenth, and eleventh graders, of low SES, in public high schools. The study suggested a frog pond effect of SES as a marker of academic ability and social worth generated and perpetuated by students, parents, and school personnel. Lower SES students were observed to be at greater competitive disadvantage in higher SES schools where they may be labeled academically or socially inferior to their peers. Students in lower SES schools were found to be less differentiated by SES due to the lack of importance placed on social and self-evaluation against their peers (Crosnoe). These results, based on data from student surveys, revealed a connection between student perception of ability and the dominance of their SES situation. Researchers concluded that SES differentiation is influential in student performance and suggested that future studies investigate whether or not situational SES status is influential on student feelings of competency.

Student Course Selection. Carbonaro and Covay (2010) conducted a longitudinal study on 13,440 students that examined sector differences in high school course taking and the resultant achievement of those students. The data, secured from the Education Longitudinal Study funded by the United States Department of Education, relied on questionnaires from students, parents, teachers, librarians, and administrators. The study concluded that public schools needed to revamp their efforts to enroll students in higher level mathematics courses if they are to measure up to private school achievement in mathematics. Researchers suggested that more rigorous challenges are vital to building a stronger understanding of mathematics concepts. However, the researchers recognized that intentions to increase enrollment in higher level courses may involve lowering the rigor of the higher level courses, thus compromising the outcomes.

A university outreach program (Davis et al., 2011) targeted low SES students for opportunities to enhance their skills in reading comprehension and application, mathematics, science, computing, decision-making, and health and wellness in Alabama. A total of 48 intermediate level students in four under-resourced counties participated in a two-week summer program and tri-monthly Saturday academies over a five-year period. The program results indicated that increased opportunities to learn and interact in the rural context, enriched with relevancy of career and life options, self-capacity, and motivation were effective in addressing the wholeness of learning for rural students. The researchers concluded that the wholeness of learning may be a feature of reform instruction that precipitates improved student outcomes. The results of the study indicated that teacher practices linked with enhancement of academic and cultural experiences may impact students' college academic readiness.

Rural and Cultural Influences on Student Achievement

A quantitative study in Australia by Fenwick (2012) demonstrated that differentiation practices brought about by schools during the transition to minimum standards often limited opportunities of students to learn. The study included students from three schools in different regions of Australia using revised curriculum in English during their last two years of school. The researchers chose English curriculum for this study because that choice rendered a larger data base since all students must enroll in English courses. Differentiation practices varied from school to school while the study indicated that a focus on minimum standards resulted in increased rigor in course work while simultaneously expecting increased student success rate in upper secondary education. Researchers concluded that teachers needed to provide increased differentiation for students from low SES or Indigenous backgrounds who might not achieve under the new literacy standards. The increased use of differentiation removed the benefits of implementing the performance assessment by restricting learning opportunities for students from low SES or Aboriginal or Torres Strait Island backgrounds. Those students from higher SES or non-Indigenous middle-class backgrounds benefited most from the curriculum reforms in Australia. The results of the study suggested that a challenging standards-based curriculum may not benefit all students equally. Though this study addressed reform practices in English course work in different regions in Australia, Fenwick suggested that similar conclusions may be expected in other standards-based courses in secondary education. Fenwick concluded that the gap between low and higher SES students on performance assessments may precipitate a need for differentiation practices. The results of this study implied that it is essential for reform practices to challenge all students to a high standard without prevailing assumptions of decreased capacity to learn based on student background.

The learning disengagement of students in Rural Appalachian Ohio prompted a qualitative study by Hendrickson (2012) intended to uncover prevalent themes among rural students in rural areas that may impact their success in school. Three recurring themes were: 1) family values and expectations, 2) quality and perceived relevance of education, and 3) misunderstandings between teachers and students. The study indicated that these cultural influences in Rural Appalachia resulted in student disengagement from learning. The study suggested that teachers who developed a sensitivity to the rural culture might use a place-based curricula suited to the needs of resistant students in order to leverage rural students' sense of community and close family relationships and promote successful student outcomes. Hendrickson (2012) attributed student disengagement in Rural Appalachia to the culture clash between teachers who valued global knowledge and rural communities who tend to value place-based knowledge. This study connected rural characteristics related to cultural influences to students' learning capacity and performance outcomes. Hendrickson suggested that the teacher-student relationship may influence positive outcomes if cultural sensitivity and appropriate curriculum are woven into the reform practices of rural math educators. Hardre (2012) contributed that mutual respect between the teacher and students is insufficient, it requires intimacy and nearness to build community and place-value. Part of being a teacher is being oriented into the culture of the students and relating learning to their world, according to rural Australian research (Green, Noone, & Nolan, 2013). This relationship is quantified in my research study and referred to as "rural connectedness of the teacher".

Summary

The literature review encompasses three venues: theoretical underpinnings, state and national artifacts, and informational essays from experts in the educational field. All three contribute meaningful perspective to research into the teaching and learning of high school mathematics in the rural context during the reform era. Theories put into practice during the reform movement have been nationally adopted and not customized to regional differences. The disparities in socioeconomics, teacher quality and training, and cultural values may have impacted the effectiveness of instruction programmed for all students but not equally appropriate for all. Scores and measurements quantifying the current condition of mathematics education at the state and national levels bring more questions regarding the equality of learning opportunities for all students. Uniform standards and scripted implementation may not lead to equality of learning opportunities nonetheless there are those who believe that equality can grow from CCSS (Schmidt & Burroughs, 2013). Experts in the educational field acknowledge the characteristics of rural students that impact the complex process of teaching and learning in the rural context.

Poverty and isolation prevalent in the rural South may reduce the effectiveness of some math instruction and intensify the usefulness of others. Research is important to document the effectiveness of reform, traditional, and a blended approach in order to tap into the rich resource of mathematical talent in rural high schools. The gap in knowledge concerning effective instruction motivating rural student college math readiness is evident in the research. Though most research studies focused on student outcomes following specific programs. The student outcomes were primarily measured by local or state tests and failed to address college readiness as indicated by a nationally recognized test. Chapter 4 addresses methods of investigation for addressing this knowledge gap.

Chapter 3: Research Method

Introduction

The shortage of science, technology, engineering, and mathematics (STEM) majors in the United States reflects a gap between the supply and demand of STEM proficient workers across the United States and notably in Tennessee (University of TN, 2011). Equipping the United States with math- and science-proficient students is a national priority designed to ease the threat to our global economic position and academic competitiveness. The rich untapped resource of potential STEM students in Tennessee presses educators to structure their high school mathematics instructional practices for improved student outcomes.

Refocusing on college readiness (CCR) accountability in high schools has led educators to reexamine student performance on assessments measuring CCR and recent work to improve student outcomes (Good, 2010; National Governors Association, 2012; Radcliffe & Bos, 2013). Surpassing the importance of economic competitiveness is the drive for equity in educational opportunities for all students (Kober, Rentmer, & Center on Education Policy, 2011). Rural students in the Southern states have consistently scored lower in mathematics on the national assessments than their nonrural counterparts (Grady, Watkins, & Montalvo, 2012; Peterson & Oessmann, 2012). Low performance in high school mathematics has discouraged the pursuit of math-oriented careers while demands for employees with math skills have increased.

The results of these factors are an increasing shortage of STEM-prepared high school graduates (Buckley, 2010; Vigdor, 2013) and a lack of college and career preparedness in general (Rothman, 2012). Reform mathematics instruction, which is grounded in constructivist theory, has responded to this globally critical problem with a variety of measures. Experts in education in the rural context have emphasized the importance of cultural sensitivity for practical instruction of rural students in high school mathematics (Howley, Showalter, Klein, Sturgill, & Smith, 2013; Leonard, Russell, Hobbs, & Buchanan, 2013). The Rothman research study considered all of the influential factors suggested by research when designing a plan to assess those deemed most important to student outcomes.

The purpose of this research study was to investigate current reform and traditional math instruction in rural high schools through one primary research question:

> What differences exist between rural student outcomes in mathematics following reform, traditional, or a blend of instructional practices as determined by assessments measuring college academic readiness?

The secondary research question was:

> How do reform and traditional math instruction impact rural students of low SES compared to rural students of high SES in regard to college math readiness?

Answering these questions required a study situated in a rural setting to gather data regarding instruction and student outcomes. The remainder of this chapter describes the research study in the context of current reform, methodology used to respond to the research questions, steps in the data collection, and planned analyses of the data.

Increased Reform Practices

The Common Core State Standards (CCSS) have been adopted by Tennessee and 45 other U.S. states (National Governors Association, 2012). These standards and a national drive for improvements in mathematics education have led to increased usage of reform practices in public schools (National Governors Association, 2012). Governor Haslam attributed Tennessee's improved elementary student outcomes to recent reforms in the state. In 2014, Tennessee's 4th graders moved from the 47th lowest in the nation to 36th lowest among the 50 states on NAEP (SCORE, 2014). This unprecedented improvement made Tennessee the fastest improving state in the nation although Tennessee's 4th graders still rank in the lower half of the nation in mathematics (NAEP, 2014). Tennessee's gains in high school mathematics were slightly above the national gains. Nearly 50% of Tennessee Algebra II students scored proficient or advanced on the state End of Course (EOC) test, up from 31% in 2011. The EOC, linked to state standards rather than CCSS, is considered an additional measure of college readiness in Tennessee. There is some overlap of content and standards from high school mathematics frameworks and Tennessee state standards for mathematics and the Common Core Mathematics Standards, (See Appendix A).

Measures of College and Career Preparedness

The American College Test (ACT) has long been a reputable measure of student preparedness for college courses in specific content areas (ACT,2014b). The average Mathematics ACT score in Tennessee in 2014 was 18.8 out of a maximum score of 36, while the national average was 21.1 (ACT, Condition of College & Career Readiness in TN, 2014). The average Math ACT score in Tennessee has improved from 18.1 in 2010 to 18.8 in 2014 (TN Department of Education, Report Card, 2014) while the nation experienced a less significant gain from 21.0 to 21.1. It is fairer to compare the average Mathematics ACT subtest score in Tennessee with the other eleven states testing 100% of their students in that year. In this comparison, Tennessee was the fastest improving in

2014 (SCORE, 2015). However, the state average score in ACT mathematics in 2014 was the second lowest result among the 12 states testing 100% of their students. In 2015, Tennessee moved to the fifth from the lowest performing among 13 states testing 100% of their students (ACT, 2015). This upward climb may be due to increased rigor of standards, tightened accountability measures, or implementation of reform math instructional strategies. All of these factors are influential in promoting college readiness. The study focused on the level of reform instruction students received. A comparison of the school where the data was collected and Tennessee state Math ACT averages indicated trends. Recall that beginning in 2010 Tennessee required all 11th-grade students to complete the ACT. The scores for Tennessee 12th-grade students, based on their last ACT testing, are given in Figure 2 (TN Department of Education: Report Card, 2015).

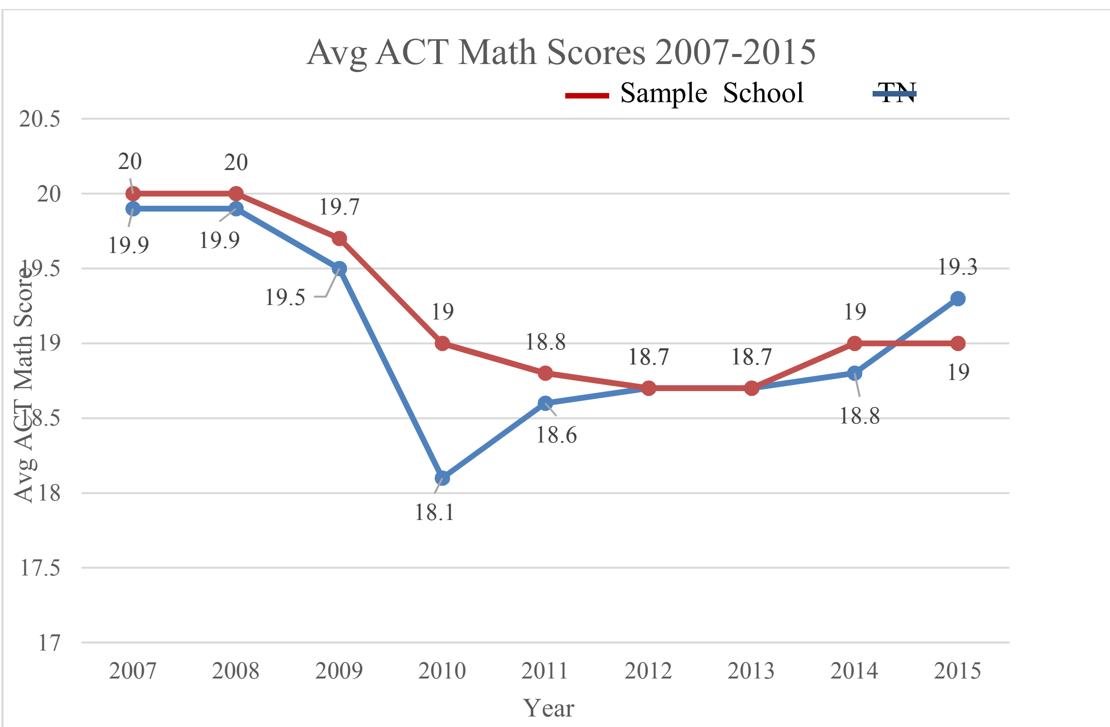

Figure 2. Average ACT Math subtest scores comparing sample school and TN averages from 2007 to 2015 report that the sample school was above the state average until 2015.

The graph illustrates the slightly superior performance of the school's 12^{th} graders on the ACT math subtest until 2015, when the Tennessee average Math ACT score exceeded the average score of the school. Statisticians state that a trend occurs when three or more consecutive data points exceed the mean value. The long-term trend for the sample school to exceed the state average in math was broken with the performance of the 2015 graduating class. Data from the research study suggested that the sample school may surpass the state mean again in 2016.

Science, Technology, Engineering, and Mathematics Focus

As a Race to the Top Award Recipient, the State of Tennessee has promoted state-wide efforts toward improving mathematics instruction, particularly STEM education (TN Department of Education, 2014). A recent report on STEM initiatives in Tennessee indicated significant improvements in expanding mathematics and science learning across grades K-12 through partnerships with stakeholders and increased awareness of STEM opportunities for students (Johnson, 2014). These studies reported increased STEM awareness but did not focus on rural student learning of high school mathematics following the full implementation of CCSS in Tennessee high schools in 2011-2012. This lack of focus is important because the vast majority of Tennessee's schools are designated as rural, and more than half of Tennessee students are economically disadvantaged (TN Department of Education, 2014). Only six of the 95 counties in Tennessee are considered metropolitan while the remaining 89 are all rural

(TN Department of Education, 2014). Also, 58.6% of Tennessee students are designated as economically disadvantaged (TN Department of Education, 2014).

In 2014, the participating school reported 35.7% of its enrollment as economically disadvantaged (TN Department of Education, 2014). The actual percentage is likely higher since this rate relies on students qualifying for free or reduced lunches. High school students are not inclined to apply for free or reduced subsidies, even though they may be eligible, causing a common under-identification of low SES students in high school (Avery, 2013). In support of this claim for under reporting of economically disadvantaged, observe the following contrasting report. The middle schools feeding into the high school participating in the research study reported an average of 56.6% economically disadvantaged students, while the high school reported only 35.7% low SES (TN Department of Education, 2014). It is unlikely that middle school students improve their socioeconomic standing by more than 20% over the summer. The socioeconomic level of the students is an important factor because low SES students historically perform lower in mathematics than other students (Howley, Showalter, Klein, Sturgill, & Smith, 2013; NAEP, 2013). Lam (2014) concluded that the socioeconomic standing of a student is predictive of academic success as early as the primary grades. The socioeconomic standing of students involved in the research was considered as a covariant factor that may have impacted student response to college math preparation. A further reckoning of this effect is found in Chapter 4.

Reform Education in the Rural South

A large rural initiative covering five Southern states, including Tennessee, (Hardre, 2012) revealed that rural students need motivation, autonomy in learning, and a perception of capacity for success. Reform mathematics instruction encourages all three of these needs (National Governors Association, 2012). However, in the reform mode of uniformly teaching all students with the same curriculum in a scripted format, educators may fail to address the place value of the rural situation (Battey, 2013; Crosnoe, 2009; Hendrickson, 2012; Howley, 2009; Jones, Irvin, & Kibe, 2009). Rural students have historically been out-performed by their nonrural counterparts in national mathematics testing reported by NAEP (2013, 2014) and state testing reported by Tennessee (TN Department of Education, 2013). The relevance of mathematics content presented in the reform curriculum may be unclear to rural students. Immediate applications may seem obscure or remote. Teachers of rural students may use reform instructional practices exclusively, traditional methods, or a blend of both constructivist and traditional. An underlying goal of mathematics instruction is the preparation of students for college or career. The CCSS acknowledge this goal (National Governors Association), citing equity of learning opportunity as a primary objective. According to experts (Grossman, Reyna, & Shipton, 2011), governors have an advantageous position to lead effective implementation of the CCSS if they unify their forces and build educator capacity. Coordinating an effective reform plan relies on strategic communication and support.

Description of the Research Study

The current study focused on instructional practices currently used by secondary mathematics teachers in a rural Tennessee high school and the college academic readiness demonstrated by their students. The quantitative study was an experimental study involving pre and post scores of students, the dependent variable, following different treatments of traditional and reform instruction in high school mathematics, the independent variable(s).

Purpose of the Study

The purpose of the research study was to examine the relationship between teaching practices in rural high school mathematics and student math preparedness for college and STEM careers. The primary research question focused on the effect various levels of reform instruction had on the college math readiness of rural students. The secondary research question focused on the same effect, given the covariate of SES status of the rural student. The researcher tested theories regarding the relationship between constructivist and traditional teaching practices as measured by teacher questionnaires and rural student mathematics readiness for college as measured by the American College Test (ACT). The ACT is a reputable assessment of college academic readiness (CCR) that provides accurate predictability of student success in STEM courses following high school graduation (Chen & Luoh, 2010; Nicholls, Wolfe, Basterfield-Sacre, & Schuman, 2010). The American College Testing Bureau openly acknowledges that the ACT is not the only measure of college academic readiness. The ACT reports accuracy in predictability of college success in the courses linked to the corresponding subtests measuring content knowledge and skills (ACT, About ACT, 2014). High school course taking has been linked with college math preparedness as taking higher level math courses in high school improves students' chances at success in college, gainful employment and greater lifetime earnings (Gaertner, Kim, DesJardins, & McClarty, 2014). Engaging rural students in career experiences, such as health care professions or other STEM careers, enables an early perspective of how their contributions can provide beneficial outcomes across multiple populations including their immediate community (Holley, 2013).

Design of the Study

The quantitative study followed an experimental design utilizing the planned variation design where individuals are treated to varied teaching practices (Frankfort-Nachmias & Nachmias, 2008). The study was confined to one rural high school setting in Southeastern Tennessee where teachers received state-wide reform math training and began full implementation of the standards based instruction in 2011. Although all teachers received the same professional development training in reform practices, implementation varied. Teacher use of technology, interpretation of practices, and individual teacher's perception of appropriateness of the practice for his/her own classes created differences in instruction. The variable use of traditional, reform, and a combined implementation enabled the researcher to examine specific practices connected to student college readiness in mathematics. The teacher questionnaire was a consolidated version of two existing questionnaires (Akyuz & Berberoglu, 2010; Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010), addressed all eight of the strategies recommended by the CCSS (see Appendix B), and incorporated the six characteristics of effective reform teaching in rural Australia (Aldous, 2008) (see Appendix B.2). Also, questions within the survey addressed all five themes of high-quality instruction in classroom core practices suggested by the ACT college readiness standards (ACT, 2013) (Appendix B.3). The modified questionnaire (Appendix C) collected data regarding teaching strategies including the use of technology in the instruction of high school mathematics and relational connectivity with rural students. The teacher questionnaire provided a measurement of the level of reform practices employed, and assessed interconnectivity with rural students. Research supports these three criteria as vital to effective teaching: teacher content knowledge, effective instruction, and interconnectivity with students.

Student scores on the math subtests: ACT PLAN and college entrance ACT tests will measure student outcomes of college academic readiness. All of these ACT sponsored tests are required and provided to Tennessee students by the state. Data linking teacher experience and daily instructional practices with student outcomes would offer a fresh perspective for educators who are transitioning to reform instruction in rural high school mathematics.

Justification for Design and Approach. The quantitative model is appropriate for this research study as the treatment of instructional practices in the rural context will provide a control group of students who received reform mathematics instruction from a constructivist oriented teacher, students who received traditional instruction, and students who received a blend of both constructivist and traditional instruction. Random assignment of students to teachers by computer generated schedules will enable every student an equally likely chance of receiving any teacher at any time of day. This random assignment will increase internal validity and confidence in the findings (Frankfort-Nachmias & Nachmias, 2008). Students enrolled in accelerated math classes are also randomly assigned by computer to accelerated classes. All student participants completed the PLAN mathematics subtest during 10^{th} grade, and the actual ACT mathematics subtest near the conclusion of 11^{th} grade. The deductive approach allowed the researcher to analyze the relationship between instructional practices and student indication of college math readiness. The reliability of the ACT enabled strong construct validity as the predictability of student success in respective college courses has been closely related to student performance on the ACT. The uniformity of constraints within the school allowed consistency of influential factors on student performance.

The research study did not intend to show causation, rather examined the relationship between teacher instructional practices and student CCR. The application of multiple regression analysis of the data enabled the researcher to inspect the influence of single factors such as student SES level, specific instructional practices, or cumulative degree of reform practices. This research project, dependent on numerical data and not observational data, was strictly quantitative in nature. Because teacher responses to questions regarding their individual instructional practices may vary over the semester, repeated questionnaires provided accuracy of teachers' responses to each question regarding instructional practices in use in the teachers' classes. Analysis of individual practices linked with student outcomes and multi-variate analysis of the composite of reform practices linked with student outcomes resulted in a thorough statistical analysis. The expected student sample size was approximately 250 students and five math teachers, based on estimations of the size of the 11^{th} grade class and the number of math teachers needed to instruct those students over the school year.

Variables

The variables of concern were those practices indicating traditional or reform practices and approaches to instruction and student readiness for college math as a consequence of those practices. Most were continuous variables, some were interval while a few were categorical response variables requiring conversion into a numerical code for statistical analysis. These conversions are further detailed in chapter four.

Independent Variable(s). The main independent variable was the usage of reform practices implemented by each student's mathematics teacher providing the treatment to the subjects. This treatment variable, measured by teacher self-reported questionnaires was administered twice during the term of instruction to increase reliability. Each teacher's level of reform instruction was an interval value relying on the sum of the teacher's responses to survey questions regarding the frequency and purpose of the particular instructional practices they employed. The index variables correlated with questions on the teacher questionnaire are use of technology, traditional and reform approaches and practices, rural connectivity and rural place value, and teacher concept of the learning of mathematics. A few covariate variables, of secondary concern to the research question, describe the student participants. These variables include socioeconomic level, gender, and selected academy of enrollment: Humanities, STEM, or Business and Medical Academy.

Dependent Variable. The main dependent variable in the study was a measure of student value-added math readiness. The data collected from student performance on the mathematics section of the criterion referenced American College Test (ACT). The dependent variable responses were the calculated differences between the predicted Math ACT score and the actual Math ACT score achieved by each student. The gain or loss between the scores ensured equity of scoring for all ability levels of students. The predicted score relied on the PLAN ACT tests administered during the students' 10^{th} grade year. Some teachers may teach honors level or advanced courses while others may have basic level classes, causing an inequitable direct score comparison. Any inequity in score comparison was minimized by using the difference between predicted and actual scores. All Tennessee students take the ACT PLAN test in the 10^{th} grade and the actual ACT near the end of their junior year of high school. It is important to the reliability of the study to keep educational measurements consistent for all students in the study (Chulu & Sireci, 2011). To achieve this goal, the research study used the value-added score to assess student achievement toward college math readiness.

Other Variables. External factors out of the researcher's control included family issues of instability or trauma, economic shifts, and vital physical or mental changes impacting learning capacity that may have occurred between 10^{th} and 11^{th} grades. It was necessary to assume a normal distribution of those influential factors among the students receiving different treatments of reform instruction. Control variables consistent within the participating sample school were rurality of the school, standards of instruction, and recent reform training of the teachers.

Connection to Research Problem

The research problem of relating elements of mathematics instruction to achievement levels of college readiness required data. Teacher data collected from the modified questionnaire provided treatment data by using index variables as indicators of teacher practices. The resulting students' ACT college math readiness was the focus of the research. Teacher practices indicated through their responses to questionnaire items regarding their actions and approaches to mathematics instruction enabled assessment of the degree of reform instruction utilized in their respective traditional or constructivist instruction of high school mathematics.

College readiness is not entirely dependent upon performance on the mathematics subtest of the ACT. However, data does support the accuracy of those scores in predictability of college freshman performance in college algebra. Benchmarks set by the ACT indicate the necessary score to predict potential for earning an A or B at the entrance level course of college algebra. Notice in Table how the benchmarks vary by ACT version provided at different grade levels.

Table 1

ACT Benchmark Scores for Mathematics Subtests

Exam	Grade Level	Benchmark Score
ACT EXPLORE	8	18
ACT PLAN	10	19
ACT	11	22

Adapted from American College Test (2014b).About ACT. Available at http://www.act.org/aboutact/

Connecting Various Influential Factors. Multiple regression analysis allowed investigation of possible influential factors on student math performance. The researcher investigated the relationship between the Math ACT score and student characteristics of gender, SES level, academy connection, and gender. Teacher characteristics, including reform training received and awareness of rural culture were considered as possible influences. Other factors suggested by research as key factors impacting rural student success were use of class time and connectivity with rural students. These factors were analyzed individually for a possible influence on student outcomes as well as the individual and summative measures of the index variables for each teacher.

Setting and Sample

The setting for the experiential study was one rural high school in Southeastern Tennessee. The school population was large enough to provide a student sample of approximately 350 11th graders and eight math teachers charged with preparing those students for college during their 11th grade year. The rural school has at least 30% economically disadvantaged students, has been in transition to reform mathematics instruction from 2009 to 2014, and has full implementation of both Tennessee and Common Core Mathematics standards.

Description of Population and Sample. Eleventh-grade students and their teachers in one rural Southeast Tennessee high schools are the population of interest. The number of expected student participants at the participating high school was approximately 250 students. Common Core training for all mathematics teachers in Tennessee followed adoption of CCSS in 2009. Tennessee high school mathematics instruction aligns with both state and CCSS (see Appendix A). Teachers and students are still accountable to Tennessee standards for the End of Course (EOC) in Algebra II, the course most students take during their 11th grade year. Students on the advanced track may have completed Algebra II during 10th grade and then enroll in either Pre-Calculus or Statistics during 11th grade. The proposed participating school was on block schedule where a one-year course is completed in one semester. Some 11th graders had completed their mathematics course during the fall term and some were enrolled in mathematics during the spring term. The sample was taken from all 11th graders at the selected high school enrolled in a mathematics course during the 2014-2015 school year.

Sampling Method

The sample school had a demographic profile similar to others in the state when comparing enrollment, graduation rate, and SES level.

Table 2

Comparative 2014 Demographics for the Participating High School

Demographic Category	Tennessee Total	All Schools in Participating County	Participating High School
Student Enrollment	993,841	3,107	1,533
% White	66%	91%	93%
% Black	24%	4%	4%
% Economically Disadvantaged	59%	55%	36%
ACT Composite*	19.2*	18.6*	19.6*
ACT Math Subtest*	18.7*	18.3*	18.8*
Graduation Rate	87%	93%	94%

*Scores are for graduating seniors in 2014 and based on 3-year cumulative average 2012-2014 (TN Department of Education: Report Card. Accessed at http://222.tn.gov/education/dat/report_card/index/shtml.

A couple of students were not enrolled in a math course on campus and several others did not have either a PLAN or ACT score, reducing the sample size and introducing a potential threat to internal validity.

The achievement level on the Math ACT was comparable to the state average. The ethnic percentages of the high school were not similar to those of the state so the research study did not encompass ethnic data. Demographics and ACT scores of the sample high school (TN DOE, Report Card 2013-2014) indicated that the school was fairly representative of schools in the surrounding county and across the state. The enrollment and economically disadvantaged (ED) percentage indicated for Tennessee includes all students in public schools, grades K through 12. The disparity in SES levels between the entire state and the high school was due to the fact that the state level relied on all students K through 12, while the high school level relied only on the high school SES level which, as explained earlier in this section, may be under-reported.

Sample Selection and Sample Size. Random assignment of students to teachers ensured equally likely opportunities for various levels of reform instruction. Student participants were in classes of average size in compliance with Tennessee state regulations limiting class size. Computer assignment of students to classes enabled a simple random sample. The exceptions were those students who enrolled in accelerated classes and were limited to the advanced instructional teacher(s) for that course. The randomized assignment of students allowed an equally likely chance for students to receive various treatments of reform instruction.

Ideally, the sample of students would have been a census of the 11^{th} graders in the school. Not every student had pre and post ACT scores on record due to absence on the test date or the student was a transfer from a state where the ACT PLAN test was not required. To achieve a medium effect size of .25, $\alpha = .05$, with an accepted power $(1 - \beta) = .80$, the necessary sample size was calculated as 269 using G-power analysis software (Faul, Erdfelder, Lang, & Buchner, 2007). The student sample size, after excluding those students with missing pre or post test scores, was 312, which exceeded the requirement.

Description of Data. The research project involved collection of teacher data regarding instructional strategies and class protocol as assessed on teacher questionnaires. The questionnaire used (see Appendix B) was a composite of two surveys used to assess reform practices used by teachers (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010; Akyuz & Berberoglu, 2010). The surveys were modified to address reform elements. These elements included the eight Mathematical Practices Supporting CCSS for High School Mathematics, the six characteristics of effective teaching in rural Australian schools from Aldous (2008), and the five themes projected by ACT for high-quality classroom core practices (see Appendix B.3). Requests to conduct the research project at the school followed the proper chain of command. The researcher requested permission from the director of schools, the system mathematics coordinator, the principal, the guidance testing coordinator, and 11th grade teachers of the selected high school. Actual surveys were conducted via paper copy rather than online, at the recommendation of the school principal. Student anonymity was achieved when acquiring data regarding their predicted and actual ACT scores in mathematics. The ACT data was interval in nature as were the difference scores discussed earlier. Entry of data into spreadsheets preceded SPSS data analysis. Teacher responses to the questionnaires enabled individual cumulative scores of reform practice usage. Data entry into a spreadsheet enabled multiple regression analysis relating any combination of the practices with student added-value scores on the mathematics ACT subtest. Disaggregating the data by gender, SES level of student, and student choice of academy required assignment of coded values to transform nominal data into ordinal points for investigation as independent variables.

Defense of the Methodology

The relationship between teacher practices and student outcomes was examined within three dimensions: technology and reform instructional practices, teacher concept of the learning of mathematics, and the rural cultural connectedness of the teacher. All independent and dependent variables are quantitative measurements. Use of multiple variables enables a broader inspection of influences on student outcomes. Any correlation coefficients obtained would have assessed the strength of the relationships.

Defense of Sample Size

The sample size of 368 students was sufficient to supply several discrete groups by class. Student assignment to classes was randomly done by computer so students had an equally likely chance of assignment to classes of various levels of reform instruction. Repeated sampling of teachers ensured the accuracy of their responses regarding teaching practices in use in their respective classes.

Defense of Usefulness of Research

The information gained through the study were extremely helpful to the school in determining the relationship between instructional practices and student college and career preparedness. The results of the study assist administrators and teachers in various ways in future decisions. The findings support curriculum selection, identify effective practices with rural math students and target needed professional development for teachers. Recommendations from the research may equip math teachers with insights into their individual instructional effectiveness toward preparing students for college or career. Support materials for professional development in reform curriculum (Hirsch Lappan, & Reys, 2012) are available to educators and research needs to be ongoing.

Researchers (Zhang & Stephens, 2013) have identified four components essential to robust implementation of reform mathematics instruction: knowledge of mathematics, accurate interpretation of the math curriculum, clear understanding of students' mathematical thinking, and capacity to design appropriate instruction. These criteria require training and ongoing professional development with access to support resources. The current research intends to amplify the need for meeting all four components essential for effective reform math education.

Eligibility Criteria for Participants

Students at the high school were eligible to participate if they met three criteria:

- Student was enrolled in 11^{th} grade during the 2014-2015 school year.
- Student had on record a pre ACT math subtest score from 10^{th} grade.
- Student obtained an ACT mathematics subtest score in the spring of 2015.

Each student was assigned a coded number to replace the name of the student on the data released to the researcher by the cooperating guidance personnel.

Teachers eligible to participate in the research study had direct instructional time with 11^{th} graders during the current school year. Teachers granted informed consent through response to the questionnaires. The identity of the teacher was not disclosed in the research study nor the final report submitted to the cooperating school. Rather, the final report to participants provided conclusions regarding the relationship between instructional practices and student outcomes.

Characteristics of the Sample. The sample, taken from a southeastern Tennessee rural school, included students of different ethnicities, SES levels, and gender. The demographics of the school were comparable to other schools in the southeastern region of Tennessee (see Table 1).

Student Sample. The sample size was 312 students meeting all eligibility requirements. The students were enrolled in either algebra II, statistics, pre-calculus, or calculus at the sample school and were associated with one of three different academies: Humanities, STEM, or Business and Medical Academy. Choice of academy was a student decision based on present career interests. Students in the STEM Academy were expected to have a slight advantage in mathematics since student choice of academy reflects interest in that content area. Students' interests generally connect with their higher achievement areas. All students in the sample had scores on record from the math PLAN or EXPLORE ACT test and completed the Math ACT in March 2015.

Teacher Sample. Teachers in the sample were state certified teachers who held Bachelor's degree or higher, and had received reform instruction training. The number of teachers depended on the assignment of 11^{th} graders during the school year of the research. The researcher expected a total of three to five teachers while the sample produced six teachers out of a total of eight candidates.

Data Collection Tools

Tools for data collection included the questionnaire and school reports from the American College Testing program. The teacher questionnaire assisted in determining the measure of reform instruction implemented in the classroom. This tool relied on some items from the questionnaire by Jong, Pedulla, Reagan, Salomon-Fernandez, and Cochran-Smith (2010) used to determine the reform teaching operations and protocol (RTOP) of teachers. The RTOP instrument (Jong et al., 2010) included questions regarding background information, contextual background, lesson design and implementation, content, and classroom culture. The original hierarchial linear model instrument (Akyuz & Berberoglu) was used to assess teacher knowledge and connectivity with students. Teacher knowledge has been identified as a vital indicator of student success (Metzler & Woessmann, 2010). Three categories of variables were included in the Akyuz and Berberoglu questionnaire: a) teacher characteristics, b) classroom teaching practices, and c) classroom characteristics. Both questionnaires proved reliable in their respective studies. Akyuz and Berberoglu (2010) applied a one-way ANOVA with random effects model to investigate teacher effect and class factors on student achievement both within and between classrooms.

The survey questions provided an adequate basis for the research study conclusions. The questionnaire used by Jong and others rendered data subjected to correlation analysis with significant *r* values supporting the researchers' conclusions. Both instruments contributed questions regarding teacher reform practices in mathematics. The current research study needed an instrument dedicated to targeting distinct reform instructional practices in professional practice as well as identifying those activities which establish relational connectivity with rural students. A consolidated, modified questionnaire served as the instrument for reporting teacher usage of reform mathematics instructional practices to the researcher. The questionnaire employed all six of the characteristics of effective teaching concluded by Aldous (2008) in his research with rural Australian students (see Appendix B). It also addressed CCSS and ACT high quality practices (see Appendix A). The questions were all multiple choice format or numerical response. Repeated implementation of the questionnaire established reliability of teacher responses and strengthened internal validity of the findings of the study (Frankfort-Nachmias & Nachmias, 2008).

Instrumentation and Materials. Student data included individual 10th grade ACT PLAN mathematics subtest scores and ACT mathematics subtest scores attained near the end of 11th grade. Access to these scores was through agreement with the system administrator, the school principal, and the school guidance counselor who assisted with de-identifying students. The researcher sent email invitations for participation in the research and requests for access to student data to the system director of schools, the principal of the selected high school, and the guidance director of the school. The cover letter (see Appendix D) introduced the research project to the system administrator. An informed consent form for teachers explained the purpose, expectations, and benefits of the research study. All participation was voluntary and no compensation was provided to participants. A summary of the research findings was offered to the administrators and teachers involved.

Description of Data

The data collected from ACT scores was interval in nature while teacher questionnaire responses were ordinal or nominal in nature. Counts of use of specific instructional tools and practices formed discrete data used for multiple regression analysis. Questionnaire responses from teachers that were nominal in nature were transposed using a dummy numeric code for analysis purposes. The pre and post-test format supported a pure experimental approach for examining any relationship between individual instructional practices and student outcomes of college math readiness.

Validity of the Teacher Questionnaire

The researcher addressed three types of validity essential to establishing the validity of the teacher questionnaire responses. Fifty-eight items on the questionnaire assessed teacher use of instructional practices while two items assessed eligibility. The 58 reform assessment items addressed CCSS recommended practices (Appendix B), research-based effective practices for rural students (Appendix B), and ACT recommended practices for high quality instruction (Appendix B). Table 3 summarizes the correlations between practices and questionnaire items.

Table 3

Teacher Questionnaire Items Correlated with CCSS, ACT, and Effective Rural Practices

Practices	Correlated Teacher Questionnaire Items	Total
CCSS Practices	4, 9, 10, 13–17, 19–21, 23, 24, 39, 43–45, 49–52	21
ACT Themes	4, 9, 13, 18, 21, 25, 34, 35, 39, 40, 43, 44, 47,48	14
Effective Rural Practices	3, 4, 10, 11, 13, 17, 19–24, 37, 39, 42–44, 46, 52–60	27
Research-Based Practices	5–8, 12, 22, 26–33, 36, 38, 41, 45	18

Some questionnaire items were linked with more than one practice category, thus accounting for a total of more than 60 correlations with only 60 questionnaire items. Mathematics practices promoted by CCSS indicated student activity or engagement in the learning process. The questions correlated with CCSS practices required the teacher to assess classroom implementation of these practices. Questions correlated with ACT practices directed attention to core teacher practices indicating high-quality instruction. Questions correlated with effective practices in the rural context described the curriculum and classroom interaction directed toward developing rural student learning capacity, as well as teacher awareness of the rural culture. Other research-based practices referred to effective practices supported by research studies described in the literature review. Traditional practices referred to those instructional practices commonly in use over the past generation prior to recent reforms and implementation of CCSS in Tennessee. The Teacher Questionnaire (see Appendix C) contained 60 items; 2 were teacher inquiries about whether they taught 11th grade math this year and whether they had received reform math instruction, 16 were Traditional Practice Indicators, 20 were Reform Practice Indicators, four indicated Traditional Approaches, four indicated Constructivist Approaches, and six indicated Rural Place Value. The researcher expanded Table 3 to give an item analysis with the associated constructs and correlated traditional or reform practices (see Appendix C). This item analysis provides literature references to support each construct.

Content Validity. There are three types of statistical validity vital to research: content, empirical, and construct (Frankfort-Nachmias & Nachmias, 2008). Content validity required that the instrument cover all indicators of instructional practices: reform or traditional. Both face validity and sampling validity contributed to the content validity since the questions were either derived from one of two proven questionnaires or they were linked to high quality teaching practices suggested by CCSS (see Appendix B), research on effective practices in rural and remote areas (Aldous, 2008) (see Appendix B), or ACT themes (Aldous, 2008). Empirical validity was also essential to the research.

The relationship between the measuring instrument and the measured outcomes provided opportunities to quantify the correlations between instructional practices and student outcomes. Predictive validity was only assessing the expected results against some other external criterion. The researcher had no expectation of the strength of traditional or reform practices toward CCR as reform instruction relies heavily on constructivist theory, relatively new to the rural school instructional framework. The emphasis on constructivist approach and practice does indicated that reformists consider their practices superior to traditional practices in preparing students for college mathematics. Whether the effectiveness prevails in the rural situation was not determined prior to the research. Construct validity was essential for the findings of the measurement to have more than descriptive value. Use of the known-groups technique by injecting questionnaire items already supported by research as related to traditional or constructivist behaviors allows the researcher to increase construct validity (Frankfort-Nachmias & Nachmias, 2008).

Predictive Validity: The researcher estimated the predictive validity of the questionnaire items, linked to either traditional or constructivist approach or practices, would have a significant correlation. Computation of this correlation coefficient would then render the predictive validity of the instrument.

Construct Validity: Items on the questionnaire measured hypothetical constructs of reform practices that may or may not have been available or used by the participating teacher. Responses relied on the integrity of teachers as they examined their daily practices. A repetition of the questionnaire indicated less than 2% change in responses from the teachers' first responses.

Data Collection and Analysis

Teacher and student data collection followed approval by the Institutional Review Board (IRB; IRB approval #: 06-02-15-0190876). I handled distribution and collection of the teacher questionnaires at the school. The principal recommended a paper survey over an online survey, stating that teachers were more likely to respond to a paper survey. The researcher distributed paper survey via teacher mailboxes following an email invitation to all math teachers explaining the purpose and extant of the study. Teachers returned the surveys in researcher-provided, stamped, pre-addressed envelopes. Return of the questionnaires indicated consent to participate and participants retained individual informed consent forms. A lack of response to the questionnaires posed a potential threat to internal validity but participation supplied the study with sufficient data from an ample number of teachers.

Collection of student data was at the convenience of a cooperative school guidance counselor whose authority enabled access to student data. De-identified data released to the researcher included students' PLAN and ACT math subtest scores, academy of student choice, socioeconomic status of students, gender, and math teacher during the current school year. The cooperating counselor signed a privacy agreement and all data was kept in a locked box at my residence, where it shall remain for at least five years, per agreement with Walden Institutional Review Board (IRB).

Sequential Plan

I developed a sequential plan to collect, store, and analyze the data.

Step 1: Contact School System Administrator to request permission to conduct research study. Following approval, contact school principal via email to explain the purpose of the research. Follow up the email with a scheduled in-person conference.

Step 2: Obtain signed permission and confidentiality forms from school authorities to conduct research and release student de-identified data.

Step 3: Invite 11th-grade math teachers to participate via email accompanied by informed consent forms.

Step 4: Distribute teacher questionnaires. Collect teacher questionnaires and student data. Store all teacher and student data in locked files at the home of the researcher.

Step 5: Clean and prepare data for analysis.

Step 6: Consider all possible statistical tests suitable for data analysis. Employ SPSS data analysis software. Use bi-variate regression, multiple regression, and factor analysis to identify correlations between the independent and dependent variables. Employ multivariate analysis to determine relationships which may appear with categories of data. Use ANOVA to determine the variability of influential independent factors of student demographics or teacher characteristics. Consider the cumulative influence of paired or grouped factors, as well.

Step 7: Present the results of the data analysis in tables representing the strength of the correlation between independent and dependent variables.

Step 8: Interpret the results from the statistical tests and draw conclusions based on the statistical significance of each test. Identify possible explanations for findings and discuss implications for teacher practices concerning rural high school mathematics students.

Step 9: Discuss potential changes as a result of the conclusions of the study toward selection or creation of curricula appropriate for rural high school mathematics students. Suggest possible programs to address inequities of instruction (Neuman, 2013) so that teachers share practices and have opportunity to examine the usefulness of the findings. Alert participating school of availability of research findings. Speculate on the need for future research to extend the findings of the research study to other rural high schools across the state and nation.

Protection of Participants' Rights

All teachers who submitted consent through return of the teacher questionnaire were guaranteed protection of individual rights. Teachers retained personal copies of the email explaining the purpose and extant of the research study.

Teacher Privacy. Sensitivity to teachers' privacy is vital to the validity of any research. Teachers invited to participate in the research study were given informed consent forms to explain the purpose of the research, risks and benefits of participating, and an opportunity for questions. Each school and the participating teachers had the opportunity to request a copy of the research findings. To secure their individual identities, the researcher assigned each teacher a code unknown to the other teachers. None of the individual teachers' data or responses to questionnaires has been disclosed to anyone other than the researcher. With the assistance of the cooperating guidance person, the name of each student's teacher was coded and released to the researcher, who then recoded the identity to secure anonymity. Participation in the research will have no impact on the teachers' future evaluation(s). No evaluator will receive research findings indicating teacher identity. With this procedure the researcher knows the identities of teacher participants and only student coded numbers of student participants. I agreed to provide a comprehensive report of the results and interpretive presentation to the school's math department, school administrators, and system math coordinator. Plans are underway to complete this dissemination in 2016.

Student Confidentiality. To ensure confidentiality of students the guidance teacher de-identified student data. For example, a student assigned a three-digit number 102 had the same 102 assigned as the identification for all released test scores. The students remained anonymous to me and the agreed confidentiality of the guidance counselor protected the students' privacy.

School Anonymity. The name of the participating high school was kept private and known only to me as the researcher and the involved participants. School demographics, average ACT scores and teacher characteristics do not identify the school system or school by name. The school was only described as a rural public high school in Southeastern Tennessee. All counties in this region of Tennessee are described as rural, and only six of the 95 counties of Tennessee are described as metro counties (TN Department of Education, 2013). As a result, it is improbable that any of the provided data could be used to identify the participating school.

Summary

This quantitative research study regarding teacher instructional practices and student outcomes of college and career preparedness required data and appropriate statistical multivariable analysis. Quantifying the extent of reform or traditional instruction of teachers required teacher self-assessment through an appropriate tool. The teacher questionnaire (Appendix C) addresses traditional practices, reform practices, CCSS student expectations, and ACT high-quality teacher practices. Student data consisted of scores on the mathematics subtest of the ACT PLAN test administered to all 10th graders and the ACT administered to all 11th graders in Tennessee. The researcher collected the sample from a rural high school in Southeast Tennessee similar in demographics and past ACT performance to the state averages. Informed consents from teachers and administrators enabled access to de-identified data. Cooperation of the school guidance coordinator was essential to securing de-identified data. Items on the teacher questionnaire link to CCSS practices, ACT core practices of high-quality instruction, or research-based effective practices in the rural setting. To equalize student outcomes, the researcher used the score found by subtracting the math subtest score on the PLAN ACT from the actual ACT. This difference score produced a "value-added" score. Other student factors included socioeconomic status, gender, and student choice of academy at the school. Analysis of the data, assisted by SPSS software, required several statistical approaches to investigate relationships between single and collective factors of instruction and student outcomes. The next chapter contains a detailed report of all statistical analyses and findings of connectivity between instructional approaches and student outcomes.

Chapter 4: Results

Research Questions and Hypotheses

The purpose of the study was to enable educators to prepare an increased number of STEM-ready rural high school graduates by identifying teaching strategies that motivate improved outcomes for rural learners. In this section, I restate the research questions and hypotheses, describe the research tools, data collection, and present the data analysis with findings. The primary research question (RQ1) for this study asked, "What differences exist between rural student college mathematics readiness following traditional, reform, or a blend of instructional practices?" Two related hypotheses were tested:

- $H1_O$: There is no significant difference in the Math ACT subtest score for rural students receiving traditional, reform, or a blend of both math instructional practices.
- $H1_1$: There is a significant difference in the Math ACT subtest score for rural students receiving traditional, reform, or a blend of both math instructional practices.

The secondary research question (RQ2) for this study asked, "How do college readiness measures compare for rural students of low SES status and rural students of higher SES level following traditional, reform, or a blend of math instruction?" This question further examined a covariant: student socioeconomic status. Two related hypotheses were tested:

- $H2_O$: There is no significant difference in the ACT math subtest scores for rural students of low socioeconomic status and those students not of low socioeconomic status following math instruction that is traditional, reform, or a blend of both practices.

- $H2_1$: There is a significant difference in the ACT math subtest scores for rural students of low socioeconomic status and those rural students not of low socioeconomic status following math instruction that is traditional, reform, or a blend of both practices.

Variables

The dependent variable (DV) was the value-added measure of college math readiness of the students following various levels of reform and traditional instruction, an interval measure (difference between the ACT math subtest score and the PLAN math subtest score). The main independent variable was IV1, the total measurement of reform instruction used by the teacher. Subdividing the items used to calculate IV1 enabled subgroups represented by the other seven independent variables. The IVs were:

- IV1: Total Reform Level of Instruction, (Interval measurement)
- IV2: Reform Strategies Used during Instruction, (Interval measurement)
- IV3: Technology and Reform Strategies Used during Instruction, (Interval measurement)
- IV4: Level of Rural Connectedness of the Teacher (Interval measurement)
- IV5: Teacher Concept of the Learning of Mathematics (Interval measurement)
- IV6: Student Gender (Male = 0, Female = 1; Nominal measurement transformed into coded numerical data)

- IV7: Student SES status (low SES status = 0, higher SES status = 1; Nominal measurement transformed into coded numerical data)
- IV8: Student Choice of Academy (STEM = 1, Business/Medical = 2, Humanities = 3; Nominal measurement transformed into coded numerical data)

Subgroups of the Total Reform Level of Instruction were four subgroups of independent variables. I included the independent variables of SES status in order to answer the secondary research question. I also selected the independent variables of gender and academy of student preference because they occurred on the de-identified data sheets provided by the study site's guidance counselor.

Research Tools

The measurement of student college math readiness was the value-added measurement of the difference in the score on the ACT PLAN math subtest taken in 10th grade and the score on the ACT math subtest taken in 11th grade. The measurement of teachers' use of reform instruction relied on the teachers' responses to questions regarding four topics of reform supported by current literature. Those four topics were:

- reform and traditional instructional practices (Akyuz & Berberogluz, 2010; Jong, Pedulla, Reagan, Salomon-Fernandez & Cochran-Smith, 2010),
- constructive use of technology (Aldous, 2008),
- teachers' reform concept of learning (Akyuz & Berberoglu, 2010), and
- the teachers' connectedness to the rural community and culture within which they taught (Barter, 2014; Leonard, Russell, Hobbs, & Buchanan, 2013; Howell, Showalter, Klein, Sturgill, & Smith, 2013).

The items on the questionnaire (Appendix B) relied on CCSS Recommended High School Mathematical Practices, Six Effective Teaching Practices in Rural and Remote Areas, ACT Core Practice Framework of High Quality Instruction, and ACT Core Practice Framework of High Quality Instruction.

Data Collection

The sample data from a representative rural high school in Southeastern Tennessee involved both teacher data and student data. Teacher data was from the 2014-2015 school year and student data was from their 10th- and 11th-grade test scores from 2013-2014 and 2014-2015, respectively. Eight teachers instructed 11th graders during the school year. Six of the eight teachers responded, yielding a response rate of 75%. The total 11th-grade enrollment for the school year was 379 students. Data from all eligible students with ACT scores on record resulted in a participation rate of 312 out of 379 (82.3%).

Student Data. I obtained archived student data from the study site after obtaining system, administrator, and IRB approval. Scores from ACT PLAN and ACT math subtests and other student data were stored securely in electronic files managed by the study site's guidance department. With the assistance of a cooperative guidance official at the school, I obtained a release of student data that included ACT scores, SES status, gender, academy of student choice, and math teacher during the current year. The guidance liaison de-identified student data prior to delivery to me. Attendance records indicated that all 11th graders enrolled in math had an attendance record of 75% or better, so all students met the attendance eligibility requirement of the study.

Teacher Data. After obtaining IRB approval from Walden University (Approval #: 06-02-15-0190876 and Expiration #: 06-01-16-0190876) and system and school administrators' permission, I invited teachers to participate via an introductory email message using the school directory of email addresses for math teachers. An informed consent document attached to the email explained the privacy of teacher responses. I distributed questionnaires to teachers via personal delivery of the paper questionnaires to teachers at the school. Teachers choosing to participate in the study returned their responses to me in postage-paid, self-addressed envelopes. The initial plan had been to repeat the questionnaire at intervals across the semester but time constraints forced the repeat questionnaire to be within one week of the first questionnaire. Plans with the system coordinator are in progress to present findings of the questionnaire to the math department and interested administrators in 2016.

Teacher Questionnaire. The study instrument consisted of a 60-item questionnaire for the teachers' self-assessment of their individual levels of reform instruction. Item one was an inquiry to ensure the teacher instructed 11th-grade math students during the 2014-2015 school year. Item two was an inquiry to ensure teachers had received reform mathematics instructional training. The remaining 58 items linked directly to those research-based criteria described earlier. Six of the eight 11th-grade math teachers at the high school completed the voluntary questionnaire (Appendix C) whereas the initial plan was for a census sampling of teachers. I removed questions regarding years of experience and degrees held in order to disable identification of the participating teachers, given the small sample size.

Description of Sample Data. The sample from the rural Southeast Tennessee high school was demographically similar to that of the state as a whole, with a total sample of 312 11th-grade students and six teachers. The six teachers who participated in the questionnaire were experienced certified Tennessee teachers who had received reform math instruction training. The 312 students were 11th graders who had recorded scores for the ACT PLAN and ACT math subtests. Participating students were enrolled in 11th grade math courses: Algebra 2, Geometry, Statistics, Precalculus, Calculus, AP Statistics, or AP Calculus AB, during either the first or second term of the 2014-2015 school year. The high school is on a block schedule where students complete a full course in a one-semester term. The demographics of the participating students, representative of the state, included SES status and gender.

The participants were 50.7% female and 49.3% male; 16.8% were economically disadvantaged and 83.2% were of higher socioeconomic status, based on the eligibility data for the state's free and reduced lunch program. See earlier explanation for the likelihood of an underestimation of low SES status. Student academy membership, by student choice, was representative of the school: 95 students (25.7%) were members of the Business/Medicine Academy, 117 (31.7%) were in the Humanities Academy, and 157 (42.5%) were in the STEM Academy. The total enrollment of 11th graders in the school for 2014-2015 was 379. Eleven of the 11th graders did not have a math class on campus during the 2014-2015 school year.

The sample included data from eight math teachers who instructed a total of 368 students. Of those eight teachers, four teachers instructed the majority of the students. One teacher had thirteen 11th-grade math students interspersed among their classes. Three teachers had three or fewer 11th graders among the students in their classes during the year. Eleven students had no math class on campus during either of the school semester terms. Two teachers did not participate in the study forcing a discard of their students or use of the grand mean for the teachers' reform level. One of those teachers had taught 67 students who also had pre- and posttest scores on the Math ACT on record. The other teacher who did not return the questionnaire had instructed only two math students during the school year. The percentage of participating teachers (75%) was less than anticipated. Extra efforts to include all teachers were: sending a second survey in case the first questionnaire had been misplaced and a follow-up email reminder. Due to the timing of the questionnaire, teachers may have been pressed to complete end of the year reports which limited time to devote to responding to the survey.

Student participation was also less than 100%. Though the school had an enrollment of 379 11^{th} grade students in 2014-2015, not all of these students met the eligibility requirements for participating in the study. Eleven of the 379 students did not receive math instruction from any of the school's math teachers during the school year. The total sample of students with accompanying pre and post scores, and with teacher participation allowing for reform instructional data, was 312. Though participation rates were less than expected, the number of participants was sufficient to meet the recommended minimum sample size representing the population.

The distribution of the students, described in Table 4, indicates that a total of six teachers (75%) and 312 math students (82.32%) participated in the research study.

Table 4

Teacher and Student Participation in the Research Study

Teacher	Teacher Completed Survey?	11th Graders Instructed	11^{th} Graders with pre/post ACT scores
Teacher A	Yes	73	62
Teacher B	Yes	13	0
Teacher C	No	77	67
Teacher D	Yes	1	1
Teacher E	No	2	1
Teacher F	Yes	68	63
Teacher G	Yes	134	116
Teacher H	Yes	3	2
No Math Class	n/a	11	n/a
Total 8 (100%)	6 (75%)	379 (100%)	312 (82.3% of 11th Graders)

Fifty-six of those enrolled in a math course on campus did not have both a pre and post test score on the ACT math subtest. This narrowed the student sample to 312 students.

Procedures for Data Collection. The researcher followed standard procedures during the distribution and collection of teacher questionnaires. The collection of student data was delayed until after the school term ended and the guidance counselor had adequate time to access and de-identify the student data. All data, kept in a locked file box or a password-protected data file, are confidential to the researcher. The identities of participating teachers remain known only to the researcher, the guidance counselor, and the individual participants. The data reported does not identify students, teachers, or the participating school by name. The report to the school system followed the same protocol. The researcher will destroy all data after a period of five years, per agreement with the International Review Board (IRB).

Adjustments to Research Instruments. The research instrument assessing teacher reform level of instruction (Appendix C) had no changes or modifications made in the items on the questionnaire. Prior to the distribution of the questionnaires, the researcher added instructions for completion and return. The researcher made no changes to the instrument during the data collection or analysis. The ACT pre and post test scores were standardized scores reported to the school by the ACT. The Value-Added score was the difference found when subtracting the PLAN math subtest score from the ACT math subtest score for each of the participating 312 students. The range in value-added ACT math gains for the sample [-6, 12] indicated a diverse set of data, with a grand mean of 1.97 points gained.

Data Analysis

The researcher collected student data and ACT scores from the March 2015 Mathematics subtest and the 2014 PLAN ACT Mathematics subtest with the authoritative assistance of the school guidance counselor who had access to the official school records. The goal for student participation was 90% of those 11^{th} graders enrolled in mathematics courses during the 2014 – 2015 school year. The number of students enrolled in math and having both a pre and post ACT math subtest score totaled 312 or 84.23% (Table 4). Transferring the student data from hard copy to an SPSS file prepared the data for statistical analysis. The researcher found the value-added score for each student by calculating the difference between the scores on the mathematics subtests: the ACT, administered in spring of 2015 and the PLAN ACT, administered in spring of 2014. Codes for gender, SES level, and student choice of academy were assigned to convert nominal data into numerical dummy values.

Teacher data required entry into an EXCEL spreadsheet for sorting prior to entry into SPSS for data analysis. The researcher recorded codes assigned for categorical data and documented codes in a code book for future reference. Reverse scoring for some questionnaire items was necessary for uniformly calculating the highest value as the most reform and the lowest value as the most traditional. Edge-coding of responses on the paper questionnaires enabled accurate transfer of data into SPSS. It was necessary to summarize data points from the various different subgroups of instructional practices and develop 4-point scales (0 to 4, where the least reform and most traditional practices = 0 and the most reform practices and least traditional practices = 4). All scores were interval in nature. Subgroups from the Total Reform Practices were: Use of Technology, Teacher Concept of Learning Math, Reform Strategies, and Rural Connectedness of the Teacher.

Data Cleaning

Cleaning the data included checking attendance records for students with excessive absenteeism from class and checking for outliers. No students had missed more than 25% of instructional time and only one outlier was found in the data set of Value-Added ACT scores. Since more than 5% of the data was missing due to missing PLAN or ACT math subtest scores, the researcher opted to winsorize the one outlier to avoid further reduction of the sample size. Teacher 4 had only one 11th grader and SPSS analysis removed this case from the analysis so the researcher deleted Teacher D from the data file. When more than 5% of the data are missing, Field (2012) recommended replacing the missing data with the mean, a customary procedure to retain sample size. The group mean, when available, replaced the missing data for independent variables and the grand mean replaced missing data for independent variables where no group mean existed as recommended (Laerd Statistics, 2015). The grand mean replaced the missing data for the dependent variable. Both the original data set and the means modified set were retained and analyzed separately for comparison of statistical significances in each data set. This brought the total student sample size to 368 students and the total teacher sample size to seven, following removal of Teacher D. The next step was checking for violation of assumptions.

Assumptions. The necessary assumptions for data analysis were: normality of the dependent variable, linearity, multi-collinearity, homogeneity of variance, and homogeneity of regression. The dependent variable, value-added ACT math subtests, appeared normally distributed according to the histogram overlaid with the normal curve produced by SPSS software and shown in Figure 3.

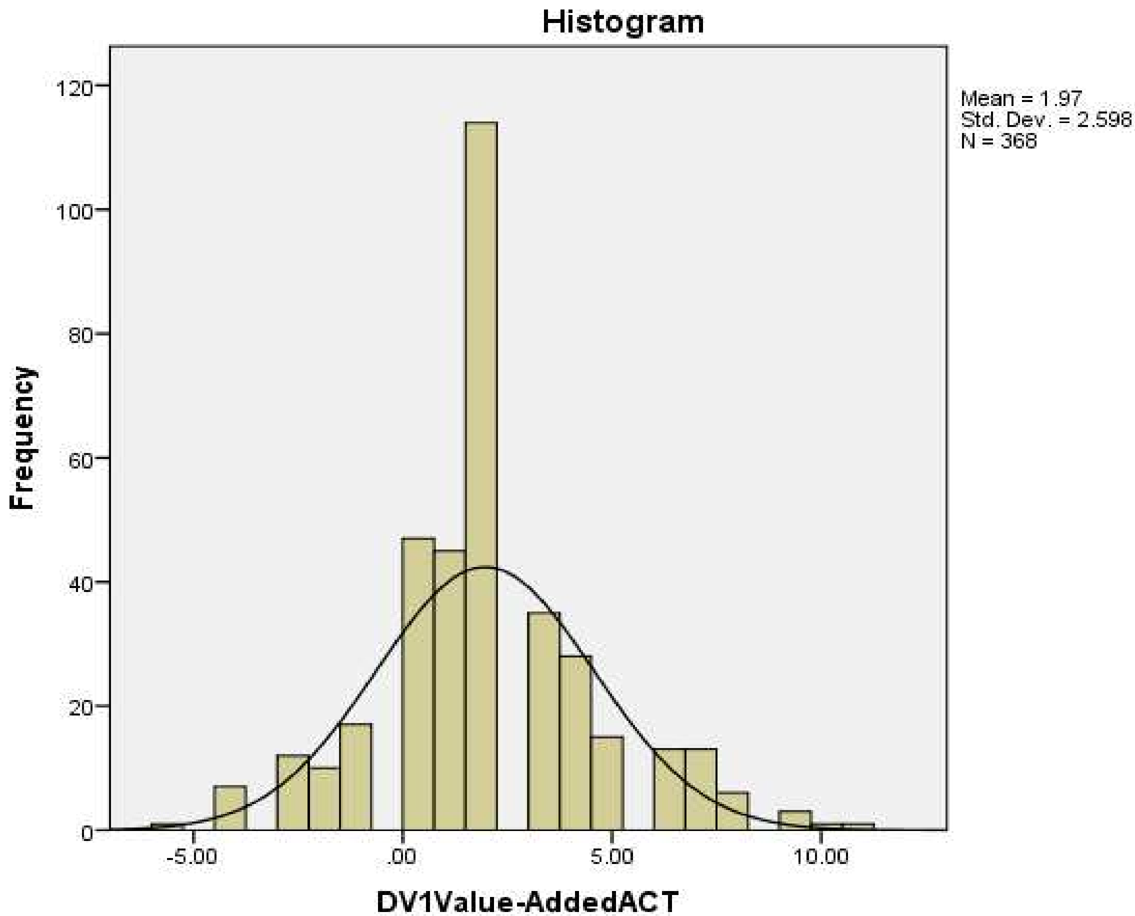

Figure 3. Normal distribution of the dependent variable (Value-added ACT scores) fits the uniform, bell-shaped curve.

The normally distributed dependent variable indicated that the school average (*M* = 1.97) did not quite reach the expected gain of 3 points from the PLAN test in 10th grade to the ACT math benchmark indicating college readiness. The high peak in the middle indicated that most students achieved at or near the mean gain of 1.97 points. This gain is an important finding from the study as I will describe later.

Linearity. The next assumption was linearity. Application of SPSS software enabled multivariate and bivariate linear tests, and ANOVA testing for linearity. The results did not yield any strong linear relationship between any of the independent variables and the dependent variable. The absence of linearity violated the assumption leading to a correlation between independent variables and the dependent variable. A report of the specific results follows.

Results of Study in Response to the Primary Research Question

All Pearson test statistics showed slight negative correlations yet none was statistically significant. There were no significant correlations between the DV, Value-Added ACT math subtest scores, and the main IV, Total Reform Level of the Instruction Received, $r = -.074$, $p = .78$. Total Reform Level was made up of four subgroups tested collectively and separately. There was no significant correlation between the Value-Added ACT math subtests and Rural Connectedness of the Teacher, $r = -.027$, $p = .300$. There was no significant correlation between Value-Added ACT math subtests and Teacher Concepts of Learning of Mathematics, $r = -.077$, $p = .071$. There was no significant correlation between Value-Added ACT math subtests and the Reform Strategies Used during Instruction, $r = -.052$, $p = .159$. There was no statistically significant correlation between Value-Added ACT math subtests and the Technology Used during Instruction, $r = -.076$. No significance between Value-Added ACT math subtests and the reform indicators was further substantiated by the Durbin-Watson test statistic, .176. These results are consistent with the literature (Akyuz & Berberoglu, 2010) in their ten-country study that found no significant variable in all countries when comparing teaching methods and techniques and student outcomes. The findings disagreed with recent literature (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010) that showed significant correlations between reformed teaching and student learning of mathematics in the urban elementary setting. In this study, the Reform Teaching Observational Protocol (RTOP) method was used to collect data during classroom observations. The current study used teacher self-reporting of their practices on the teacher questionnaire (Appendix C).

Similarly, Spearman's correlation coefficient test rendered no significant correlation between Value-Added ACT math subtests and the Reform Strategies Used during Instruction, $\rho_s = .103$. Pairing Value-Added ACT math subtests with the individual subgroups also yielded no significant Spearman correlations.

When linearity is not initially evident, another approach is to combine closely matched subgroups (Field, 2012). Naturally, strong correlations between the Total Reform Practice score and the subcategories existed. Combining categories of Technology Use and Reform Strategies into one score for a new subcategory, labeled Tech and Reform Strategies, did not yield any significant correlations with the dependent variable. The Spearman's correlation test results confirmed the nonlinearity of the relationship between Value-Added ACT math subtests and Reform Practices Received by the student in class. Ranking the outcomes of the dependent variable failed to produce any significant relationships among Value-Added ACT math subtests and Reform Practices Received in Class Instruction.

Primary Hypothesis. Failure to establish linearity resulted in failure to reject the primary null hypothesis regarding the relationship between level of reform instruction received and rural student college math readiness indicated as a value-added gain from the ACT PLAN to the ACT math subtests.

Results of Study in Response to Secondary Research Question

Prior literature supporting the close connection between socioeconomics and student achievement prompted an investigation using the data in the current study. The socioeconomic status of the students was entered as coded data for Independent Variable 8 (0 for low socioeconomic status and 1 for higher socioeconomic status). When correlating the SES status of students with their value-added gains on the ACT math subtest there was no evidence of a statistically significant correlation. The gains for students of low SES status were no different than the gains for students of higher SES status.

Secondary Hypothesis. There was little need to check the secondary hypothesis regarding differences in low and high SES students' ACT math outcomes following the various levels of treatment. As expected, Pearson's correlation coefficient yielded $r = .036$, no significance for a correlation between low SES students' and ACT math subtest gains. This lack of significance also caused the failure to reject the subordinate null hypothesis. Acceptance of the second null hypothesis acknowledges that no evidence supported the second hypothesis. The level of reform instruction for economically disadvantaged students' did not correlate with their gains on the ACT math subtest at this high school. Additionally, the students' SES level did not correlate with their ACT math subtest gains. The lack of association between SES status and ACT math subtest gains may indicate that low SES students scoring lower on the PLAN subtest gained as much as other students. The lack of correlation between test gains and SES status indicated that all students are equally eligible for interventions for increasing achievement gains toward college readiness. Again, nonsignificant results cannot be generalized to other populations outside the participating school. Since no significant correlation was found between Math ACT outcomes and reform practices students received, there was little need to check for the secondary hypothesis regarding differences in low and high SES students' ACT math outcomes following the various levels of treatment. To confirm that lack of association, Pearson's correlation coefficient yielded $r = .036$, no significance, for a correlation between low SES students' and ACT math subtest gains.

This lack of significance lead to failure to reject the subordinate null hypothesis. Acceptance of the second null hypothesis acknowledges that no evidence supported that low SES status rural students' college math readiness was predicted by level of reform instruction in the students' current mathematics class at this high school. Again, nonsignificant results cannot be generalized to other populations outside the participating school. One threat to internal validity was the nonresponse on the teacher questionnaire by two of the eight math teachers. One of the two non-responders had only two students. The other non-responder taught 67 students in the sample. This created a threat to the internal validity of the teacher responses. The lack of teacher data to correlate with 69 of the 312 student participants (22%) introduced possible bias into the research data. The non-responders' identities remain confidential to the researcher and will not be released to others.

Information from Teacher Questionnaires

The data obtained through the six returned teacher questionnaires provide a snapshot of the math teachers' instructional practices in use of technology, reform strategies, teachers' concept of the learning of mathematics, and rural connectedness to the students. Teachers' responses indicated these facts about in class use of technology:

- Teachers reported that students used an average of 2.5 different technologies during class daily.
- All teachers encouraged their students to use graphing calculators in class daily.
- Teachers reported that 66.7% of the students used graphing calculators primarily for computation.
- Teachers rarely or never used graphing calculators linked with technology.
- 66.7% of the teachers encouraged students to use technology to discover concepts prior to class presentation of the concepts.

These responses indicated there is room for incorporating more technology into the learning experiences. Teachers reported that calculator use was primarily for calculations while use of innovative graphing technologies has recently expanded to accommodate discovery learning and generate student discourse (Hillman, 2014). Rural and economic situations sometimes limit access to technology (Hunt-Barron, Tracy, Howell, & Kaminski, 2015). There was available, unused math technology at the sample school. Lack of training in the use of some math technologies limited teacher use. Literature (Joubert, 2013) supported student use of technology in the learning environment rather than teacher use in order to promote student-centered learning.

Teachers' responses reflected frequent use of several reform strategies:

- All teachers asked students to explain reasoning behind ideas during the lesson.
- All teachers asked students to write equations to represent relationships.

- All teachers encouraged students to share alternate solutions to problems.
- All teachers used multiple representations during instruction.
- All teachers used summative assessments as both learning exercises and measures of growth.
- All teachers asked students to work independently using multiple representations to solve problems.
- Five out of six teachers asked students to make sense of structure often/daily.
- Five out of six teachers asked students to analyze relationships using tables, graphs, and charts often/daily.
- Five out of six teachers used innovative, authentic assessments aligned with the curriculum.
- Five out of six teachers asked students to work together to solve problems with no immediately obvious solution.

Teachers' frequent use of reform strategies involving student engagement activities indicated a majority of teacher acceptance and adoption of these strategies. Innovative strategies foster both social and technological intelligence (Cobo, 2013). With increased collaboration, other teachers may adopt the strategies. Several strategies, such as guided ACT practices, flexibility in allowing student determination of the direction of the lesson, and discovery learning activities were not as readily integrated into daily class instruction.

Responses to several items indicated only 50–66.7% use of the following reform strategies:

- 66.7% of the teachers used targeted interventions for deficient students.
- 66.7% of the teachers aligned practices and tasks with resources other than the textbook.
- 66.7% of the teachers provided students feedback through frequent formative assessments.
- 66.7% of the teachers used proven instructional tools to support rigorous learning
- 50% of the teachers collaborated with colleagues as a primary means of improving instruction.
- 50% of the teachers analyzed or discussed student performance data with other teachers
- 50% of the teachers asked students to critique the reasoning of peers daily.

A lack of consensus on collaboration, curriculum, and use of data indicated opportunities for growth in these areas. Collaborative teaching encourages collaborative learning (Wilson, Brown, & Burke, 2013). Teacher responses indicated sporadic use of these strategies. To achieve full effectiveness, the strategies should be uniformly implemented. Responses to several questionnaire items reflect extremely limited use of reform strategies:

- One out of six teachers integrated other subjects with mathematics often.
- One out of six teachers asked students to model with mathematics often.
- One out of six teachers used student PLAN scores to plan lessons.

- One out of six teachers asked students to use discovery activities prior to introducing new concepts.
- 33.3% of the teachers planned lessons based on feedback from frequent formative assessments.

Limited use of formative assessments and PLAN scores, integration of other subjects, and discovery activities indicated a less than robust implementation of reform instruction. Teacher responses indicated room for improvement in the areas of innovative instruction, collaboration within the math department as well as with other departments, sharing of authentic learning activities, and professional development in discovery learning approaches.

Some responses indicated a traditional teacher concept of the learning of mathematics:

- Five out of six teachers reported that good math performance depends on remembering formulas and procedures, student understanding of math concepts, and thinking sequentially.
- All of the teachers reported a belief that some students have a talent for math while other students do not.
- One out of six teachers reported a belief that math is primarily an abstract subject.

A few responses indicated a contemporary teacher concept of math learning:

- All teachers reported a belief that good math performance depends on students thinking creatively.

- All teachers reported a belief that good math performance depends on students providing reasons to support their solutions.
- Five out of six teachers reported a belief that math is a practical and structured guide for solving actual problems.

The varied conceptual understanding of the learning of mathematics indicated that the teachers have contrasting perspectives that may lead to contrasting pedagogies. The unanimous agreement that creativity is essential for student success in mathematics opens the door to future professional development sessions to train teachers in strategies that promote creative and innovative student endeavor (Wood & Bilsborow, 2014). The popular belief expressed that learning of mathematics was a talent indicated that teachers' expectations were not the same for all students. This belief leads to inequity of learning. Responses to the following items indicated limited rural connectedness of the teacher:

- 50% of the teachers did not identify the school as rural.
- One teacher out of six used rural applications in math lessons.
- One teacher out of six provided opportunities for students to learn about math career opportunities in the community.
- None of the teachers provided opportunities for students to interact with community leaders to solve problems.
- One teacher out of six involved students in community activities or service projects.
- One teacher out of six included student out of class experiences in activities.

- 50% of the teachers reported an understanding the community rural culture, history, and economics.
- Five out of six of the teachers viewed math as a vehicle for students to move out of the rural community to aid the global economy.

The current reform movement toward culturally responsive teaching was not evident in the responses to items assessing the rural connectedness of the teachers. The lack of cross curriculum integration was another avenue for growth since integration of the learning of math and science into the cultural context is a powerful engagement strategy (Engstrom, & Carlhed, 2014; Yarema, Grueber, & Ferreira, 2014). There may have been teacher misunderstanding on the meaning of "rural" as it described the school and surrounding community. Responses reflected inattention to the rurality of the school and missed opportunities to incorporate community awareness into instruction. The questionnaire items related to rural connectedness and supported by current literature did not elicit responses indicative of a strong rural connectedness between teachers and their math students. Reform instruction with attention to rurality of the students could bolster the connectivity between teachers and rural learners.

Summary

The correlations between the dependent variable, student outcomes on Math ACT subtests predicting college math readiness, and the level of reform or traditional instruction received in math class were not statistically significant. I considered four subgroups of indicators of reform practices. These subgroups were: constructive use of technology in instruction, the rural connectedness of the teacher with the community, teacher conceptual understanding of the learning of mathematics, and use of reform strategies. These components, though tested collectively and individually, yielded no significant relationship with the value-added gains from the PLAN ACT math subtest taken in 10th grade to the ACT math subtest taken in 11th grade. The reform strategies and practices advocated by recent literature did not emerge as significant factors in student college math readiness as indicated by student gains from the pre to the post ACT math subtests. Similarly, there was no difference shown in the reform effects on students of low SES status. This lack of evidence to reject the null hypotheses is a finding of importance to the sample school. The highest teacher reform scores were not associated with the greatest gains in ACT math nor were the lowest teacher reform scores associated with the greatest gains in ACT math. The middle scores, representing a blend of reform and traditional practices fared as well as the highest and lowest reform effects with none showing statistical significance. The results of the connection between reform practices and student outcomes are in harmony with literature from high school studies (Akyuz & Berberoglu, 2010; Harmon & Smith, 2012). The findings were inconsistent with findings from elementary studies linking reform with improved student outcomes (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010; Grady, Watkins, & Montalvo, 2012). The link between SES levels and student ACT math gains was consistent with literature where studies correlated SES levels of high school students and national math test results (Baker & Johnston, 2011; Buckley, 2010).

Chapter 5: Interpretation and Discussion

Introduction

This research study investigated the problem of inequity in U.S. rural students' readiness for college math. Rural students in the United States have a history of lower performance on standardized tests than their urban counterparts (Howley, Showalter, Klein, Sturgill, & Smith, 2013). This lower math achievement has resulted in a STEM job fulfillment shortage in the American South (Vigdor, 2013). The promotion of reform practices and strategies to improve rural high school mathematics instruction and make math more accessible to all students has swept the United States (Vega & Travis, 2011). This movement is particularly prevalent in the South where poverty and cultural anomalies contribute to the persistent gap in performance (Howley et al., 2013). Poverty and rural values were dominant in the region surrounding the sample school. Though industry and economic growth in the area has been increasing rapidly over the past three years, the area continues to have an unemployment rate of approximately 5%, commensurate with the state of Tennessee (TN Department of Labor, 2015).

The current research study was conducted at a rural high school in southeastern Tennessee and was designed to detect instructional practices effective in promoting test performance. The study used data on student scores from PLAN and ACT math subtests taken during the 10th and 11th grades respectively. Correlating the value-added difference of the ACT math subtests with the measure of reform or traditional instruction received intended to target reform or traditional practices leading to positive gains for rural students. The results of the study did not reveal any significant association between rural student improvements on ACT math subtests and their level of reform instruction during the 11th grade.

These results were congruent with previous research studies. Several earlier studies in other school settings have yielded the same lack of correlation between reform practices and rural student outcomes on summative tests (Akyuz & Berberoglu, 2010; Baker & Johnston, 2011; Buckley, 2010). No prior studies addressed the potential relationship between the value-added gains on the ACT math subtests and the reform instruction received by rural high school students. The absence of significant findings in the current study did not permit discarding the null hypotheses but did uncover important facts about the instruction at the sample school. The contribution of educative insights about the high school in the study relied on the teachers' responses to questionnaire items and also on facts regarding the value-added gains of students from their PLAN ACT Math subtest scores in 2014 to their ACT Math subtest scores in 2015. A discussion of the findings and the implications follow.

Analysis of the study data did not show any significant difference in student gains on college readiness ACT math subtests with respect to the level of reform practices received. The predictive variables, based on cognitive and social constructivist theory, showed a very weak, slightly negative association with ACT Math subtest score gains. Interpretations of the findings cannot be substantive due to the lack of significance of the association. The results of the study suggest that other influences on student outcomes exist beyond what the study examined. An examination as to why the data failed to reflect any significance begins with the dependent and independent variables included in the study.

The variables used in the study relied on student scores and teacher self-assessment of instructional practices. The dependent variable, value-added ACT math subtest scores, relied on the ACT, a nationally recognized measure of college math readiness. The independent variable, the level of reform instruction received by the student, was supported by recent literature on reform and traditional instruction. There were four subgroups of the independent variable:

- reform strategies used
- conceptual understanding of the learning of mathematics
- use of technology during instruction
- rural connectedness of the teacher

All four constructs were rooted in constructivist theory and supported by recent literature as reform indicators. Each item on the questionnaire was linked to reform literature (Appendix C). Additional independent variables were student gender (Male or Female), student SES level (Low or High), and student choice of Academy (Humanities, STEM, or Business/Medicine Academy). Aside from the reform indicators, other potentially influential variables beyond the researcher's control may have obstructed the expected results.

Explanations for Lack of Significance

Three explanations exist for the absence of a significantly positive association between level of reform instruction and value-added gains on the ACT:

- The null hypothesis was accepted and there was no significant relationship between the dependent and independent variables.

- There were factors beyond the researchers' control that obstructed a significant effect of reform practices on student achievement.
- There were other influential factors not within the realm of the study.

Explanation 1: True Null Hypothesis. The study provided insufficient evidence to reject the null hypothesis. Statistically, this does not equate to proof that the null hypothesis is true, simply that there is insufficient evidence to reject the null hypothesis. The action of accepting a true hypothesis is a correct decision. If the decision were correct in the current study, then the level of reform used in rural math instruction does not have any bearing on the student's level of college math readiness for those students and teachers in the sample. If the decision were incorrect, then there are other possible explanations for the absence of sufficient evidence.

Explanation 2: Potential Obstructions to Reform Effects. The current math curriculum at study site may not sufficiently align with the mathematics measured on the ACT math subtest. Since this alignment was not part of the study, then no conclusion can be supported by data collected. The teachers' focus on meeting standards tested on Tennessee End of Course (EOC) and reform strategies expected by teacher evaluators have taken priority over meeting ACT curriculum, as evidenced by use of reform strategies by all teachers with little time reported spent on ACT preparation. It is possible that college readiness skills in algebra, geometry, and trig addressed in instruction do not sufficiently align with the level of cognition measured on the ACT math subtest. Tennessee educators' attention to the selection of textbooks and online resources that closely align with standards and EOC may not focus as keenly on ACT math skills. There is some overlap of EOC and ACT expectations but the two tests have different objectives.

The EOC measures basic competency skills and the ACT measures a higher order of skills indicative of preparedness for college algebra. Any compromise of alignment between curriculum and ACT math expectations could interfere with the significance between instruction and outcomes.

Teachers assessed their reform practices in responses to items on the questionnaire. Their assessment may not accurately reflect the level of reform implemented in their daily instruction. For example, a teacher who stated the daily use of several technologies may not be utilizing the technology in a reformed manner. A student using a graphing calculator independently for basic arithmetic calculations is not responding to reform-oriented practice. Whereas, a teacher-guided activity where students use graphing calculators within small groups to investigate and report algebraic or geometric concepts is a reform approach to learning math. Recall, according to Drijver (2013), mindful integration of technology assures effectiveness. The disparity in any individual teacher’s self-evaluation of instructional practices may produce an obstruction to the accuracy of the instrument. The responses do reflect a large amount of reform instruction in use at the school, as detailed in the questionnaire responses categorized earlier. The area of most collective reform was in use of direct instructional strategies that required the teacher to guide student practices. The least reform reflected in the questionnaire responses was in the area of rural connectedness to the student. Also, teachers’ conceptual understanding of the learning of mathematics was largely traditional.

Time spent in instructional contact is important to effect positive gains. The school calendar called for nine weeks of instruction in the block semester beginning in

January until the administration of the ACT in the spring of 2015. However, students missed an inordinate number of instructional days during January and February. There were an excessive number of snow days, two days of professional development, and two holidays that totaled almost three weeks. These interruptions left less than six full weeks of instruction prior to administration of the ACT on March 10, 2015. The interruptions to the schedule reduced teachers' time to less than thirty instructional days. Also, students completing their math course in December of 2014 had the disadvantage of a three-month lapse of time between instruction and ACT testing in March, risking a less than optimal performance. Some students in the sample had completed a new course at the school that provided interventions to ACT testing. Those students made positive gains on the ACT that may have skewed student results differently, independent of their math teachers' reform strategies. Both the spring semester students and the fall semester students may not have had optimal performance on the ACT in March, considering the interruptions and delays. Those few students experiencing interventions made greater gains than others. These obstructions to accurate detection of the effectiveness of reform practices were situational and beyond the control of the researcher.

Explanation 3: Extraneous Factors. Literature supports several student factors that critically influence student outcomes. Factors include home and background (Harmon & Smith, 2012), student perception of potential success (Davis, 2011, St. Clair, Kintrea, & Houston, 2013), and teacher knowledge of mathematics (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012, Marshall & Sorto, 2012). Other factors are relational interactions within instruction (Battey, 2013, Gresalfi, Barnes, & Cross, 2012), and student motivation toward school (Hardre, 2012, Hendrickson, 2012). These factors were outside the realm of the study that focused on instructional practices of teachers. What can be learned from the omission of student factors is important. Independent of teacher efforts, there are student factors yielding powerful influence on college academic readiness. The collective influence of student factors may be more critical to student outcomes than any reform strategies used by the teacher. The literature on these student factors indicate the consistent importance of each of the factors toward yielding positive student outcomes. Student factors may have obstructed the effect of teacher practices, the focus of the current research.

All teachers in the study confirmed that they had received training in reform and standards-based instruction. Active implementation varied from teacher to teacher. Individual teacher differences disrupt robust implementation of the training. Teacher perceptions of what is best for learners and the availability of technology preclude consistent implementation (Harmon & Smith, 2012). Though responses to questionnaire items may have been the same for different teachers, their implementation of specific reform strategies could have been quite different in practice, as described by the graphing calculator example earlier. The mindset of the teacher toward their use of the strategy and the potential outcome may dissuade the teacher from reform implementation.

The obstructions and outside influences that interfered with the relationship between instruction and outcomes did not make the study meaningless. Close scrutiny of the teacher response data showed information about the math instruction and performance at the school beneficial to any future improvement plan. The low reform scoring, particularly in rural connectedness of the teacher, indicated that not enough teachers used these strategies for the analysis to show a significant impact on student outcomes. This category deserves time and attention when teachers are reflecting on their opportunities for growth.

As researcher, I was looking for one or more reform strategies to show a significant positive relationship with value-added gains when the absence of such significance may have another set of inherent implications for the school. The implications include reflection of current practices, examination of rural anomalies not measured in the study, comparison of current curriculum and ACT Math expectations, and integration of science with math. I recommend an improvement plan with an emphasis on local place value and cultural sensitivity to increase student potential for college math success.

School Implications

The lack of correlation between level of reform instructional practices and student outcomes has suggestive implications that alter the perspective of rural educators and their supervisors of instruction. Tennessee has been transitioning students and teachers into reform mode since the state's early Race to the Top Award (RTTT) in 2009. The 11th graders in the study were 5th-graders during that first year of reform transition. Students have gradually adjusted to various levels of reform strategies of discovery learning, interactive discourse, defending answers, and problem-solving skills in relevant situations. Some students have experienced traditional instruction with teachers adhering to lecture, homework, and individual practice while others have experienced contemporary reform instruction or a blend of reform and traditional instruction. The long-term effect on a student receiving primarily reform instruction was no different than that of a student experiencing mostly reform instruction. The long-term effects of teachers with consistently high value-added student scores are substantive in later student outcomes (Chetty, Friedman, & Rockoff, 2011). Those students in the study who experienced strong teacher influences in prior grades would have impacted the cumulative effect of the current teacher, leading to higher or lower gains on the ACT for their students. The study limited the data on the measure of effects to the current instructional year. This limitation risked the potentiality for a significant effect of any specific reform practice measured on the teacher questionnaire.

Data reported on students' ACT math subtest scores formed a normal distribution, highly peaked in the middle. The distribution implied that the scores around the mean score, $M = 1.97$, were popular value-added gains made by the students in the study. A closer look at the data offers additional implications. The range of over-all teacher reform levels was wider than the range of student value-added gains. The reform levels of teachers, when ranked in order of lowest reform to highest reform level, indicated a broad range, from 74 to 107, where the possible range was 0 to 174. The ranking of the teachers' average value-added gains on ACT indicated a narrow range, from 1.58 to 2.33, where the data yielded individual student gains from -6 to 12. The teacher with the greatest reform indicated by the questionnaire had the lowest level average ACT gains. The most traditional teacher among the eight, with the least reform indication, had average student gains of 1.97 points from the PLAN to the ACT math subtests. These facts support the truth of the null hypothesis. There is no significant difference in student math preparedness depending on the level of reform instruction received during the year of the testing.

These results were not statistically significant yet the unexpected disconnect between reform and student college math readiness suggests that factors other than instructional practices are predictive of rural students' college readiness at this high school. Recent research indicated other influential factors on student achievement. These factors include:

- home background and motivation (Carbonaro & Covay, 2010; Grady, Watkins, & Montalvo, 2012),
- student perception of potential success in math (Park, Holloway, Arendtsz, Bempechat, & Li, 2012),
- motivation (Nomme & Birol, 2014; Usher, Kober, & CEP, 2012),
- peer approval (Davis, 2011),
- teacher competency with math technology (Raob, Al-Oshaibat, & Lan, 2012),
- individual student disabilities (Saunders, Bethune, Spooner, & Browder, 2013), and
- the nuances of a specific rural situation (Howley, Showalter, Klein, Sturgill, & Smith, 2013)

These factors enter into the undetermined predictability equation. Building a partnership between the school and the community reinforces the educational endeavor for students in small rural areas (Alleman & Holly, 2013). I encourage teachers at the sample high school to consider these alternative predictor variables when planning future goals of improved college math readiness for students at this rural high school. A recent study of Northwestern Ohio rural youth inferred the effectiveness of inclusion of rural students in early college planning (Hedrick, Light, & Dick, 2014). This is another action directed toward positive student gains that the study did not examine.

Positive School Gains

The findings of the study did not reveal a positive association endorsing reform or traditional practices as more effective in the rural learning context while there were positive school gains to report. The sample of ACT scores revealed a grand mean Value-Added ACT math gain of 1.97. The expected gain from the PLAN ACT math subtest to the ACT math subtest in 11th grade, as reflected by the benchmark scores for both levels, is almost a 2-point (1.97) gain. Recall, the benchmark score for the PLAN ACT math subtest is 18 while the benchmark for the graduating senior on the ACT math subtest is 22. The school's average gain is slightly below the expected gain of three points in order to satisfy the math benchmark score of 22. Bear in mind that the benchmark of 22 indicates college math readiness and the scores in the study came from students in their 11th grade year with an additional year of math instruction remaining prior to college entrance.

Scores collected during this study are indicative of potentially high scores for the coming year when these students are graduating seniors in 2016. The 2015 average Math ACT score for the 11th graders at this school was 19.3, an improvement over the seniors in 2014 whose average Math ACT was 19.0. The students in the study were 11th-graders with one more mathematics courses ahead in their senior year. If students simply maintain their current scores during 12th grade, the average score of 19.3 will be a five-year high score on the ACT math subtest. If they improve, on average, as much in their senior year as they did in their junior year, the school can expect an average Math ACT score of 21.27, an unprecedented high for the school. Bringing this potentiality to the math teachers' attention may incite momentum toward that goal.

The average Math ACT score for the school's graduating classes has fluctuated between 18.7 and 19.0 from 2010 to 2014 (TN Report Card, 2014). The school average has never met the ACT benchmark of 22. It will be interesting to see if the junior class of 2015, prospective 2016 graduates, maintains their average of 19.3 or continues their impressive 11th-grade gains during the final year of high school mathematics. Teacher enthusiasm toward improving student college math readiness may impact student outcomes. The findings of the research study can supply the teacher momentum needed to escalate student outcomes to a higher level.

Connections to the Theoretical Framework

Constructivist strategies reflected in the teacher questionnaire responses were prevalent among the teachers. Constructivism advocates discovery, problem-solving through investigation, the social interaction during the learning process, and student-centered activities (Powell & Kalina, 2009; Ojose, 2008; Wavering, 2011). Both cognitive and social constructivist indicators embedded in the teacher questionnaire received affirmative responses from teachers. All teachers consistently used some of the same reform strategies. All teachers asked students to reason both abstractly and quantitatively, use technology, make sense of structure, model with mathematics, and use alternate methods of solving problems. All teachers used various levels of the same traditional practices: lecture, assignment of homework, targeted interventions, and dependency on both textbooks and system curriculum for daily lesson planning. Effective planning, flexibility, and formative assessments are vital to reform instruction (Akyuz, Dixon & Stephan, 2013). There were commonalities in their practices that suggested that all of the teachers used a blend of traditional and reform instruction. Some total scores indicated more reform than traditional, yet all of the teachers' questionnaires reflected a measure of both reform and traditional practices in their daily instruction.

The variety of items reflecting teacher practices, teacher responsiveness to rural culture, ACT high-quality teacher indicators, and CCSS indicators allowed teachers to reflect on several facets of their instruction. A report to the system coordinator disseminated to the teachers will provide teachers with data supporting individual instructional changes as well as collective changes on the perception of the learning capacity of rural math students. The system supervisor and I plan to coordinate an informational session to share the results of the study with teachers at the sample school. Their reflection on practices and insights into reform strategies are worthy of consideration.

The benefits of teachers' reflection on their individual practices are two-fold: the questions brought attention to practices they are using, and it also brought attention to practices they are not using. By reflecting over the past year, a teacher may have gained insights into what practices they felt were useful and others that are still available for future implementation. The brief time taken to complete the questionnaire was productive. Reflective thinking fosters growth in the educative process. Self-evaluation is often assisted by responding to an instrument designed to assess diverse entities. Reform and traditional practices were both included in the questionnaire. Teachers' knowledge of 11th-grade ACT scores and the school average determined by the data collection will inform future decisions regarding needs for intervention classes and individual students in need of improvement.

According to the questionnaire responses, none of the teachers used student PLAN scores to plan math lessons or activities. If these scores were not readily available to them on a regular basis, math teachers may opt to change this protocol. Teachers may be encouraged to use their students' ACT scores in targeting those students in need of motivation or remediation prior to graduation or retaking of the ACT math test. Using the PLAN test scores may enable teachers to select appropriate grouping of students for discovery tasks or it may target those needing remediation in the form of extra tutoring. Such interventions may yield side benefits not intended by the research hypotheses.

Another side benefit of the study is the research-based listing of reform strategies linked to the standards, ACT quality teacher indicators, and rural place-value that contributes to culturally responsive teaching. Teachers who did not describe the school as rural on their questionnaire may be informed that the school is one of the 80% rural schools in Tennessee. The literature-referenced item analysis of the teacher questionnaire may invite further teacher research into specific reform strategies. The questionnaire responses reflected minimal attention given to connecting to the rural culture. Though this connection may not have been statistically significant as related to the ACT math subtest, literature (Aldous, 2008) supports the rural connectedness of the teacher as essential to motivation and engagement of students prior to building math competencies. Teacher awareness of the culture in which students live and the potential employment opportunities beyond high school and college entice connections between math learners and community.

Instead of the mindset demonstrated by most of the teachers that mathematics is "a vehicle to move from the rural area to aid the global economy", teachers may adopt the mindset that students can use their mathematics to improve the local community. This latter mindset is a reform notion that implies there is place value in the rural community, an important strategy for reaching rural students (Grady, Watkins, & Montalvo, 2010). The increased engagement of rural student learners through rural connectedness does not directly increase ACT math scores but it does generate interest in STEM career opportunities in the immediate community. STEM deficiencies were an underlying problem voiced earlier in the purpose of the study. All teachers indicated that they had not involved students in community activities or service projects and they had not provided opportunities for students to interact with community leaders to solve community problems as recommended by research supporting culturally responsive instruction (Avery, 2013; Barter, 2014). Only one teacher responded positively to frequent use of rural applications relevant to students and only one other responded positively to incorporating student out-of-school experiences into meaningful classroom activities. These strategies promote rural connectedness of the teacher and student (Howley, Showalter, Klein, Sturgill, & Smith, 2013). Limited utilization of these connectivity strategies proven effective in engaging rural learners limits teachers' chances to motivate optimal student results at this rural school.

Another indicator on the questionnaire where teachers responded consistently with traditional responses involved the concept of the learning of mathematics, measured by questions 26 through 33. The traditional beliefs were that mathematics is abstract, sequential, requires a natural talent, and that student success relies on memory of algorithmic processes and formulas (Akyuz & Berberoglu, 2010). Most of the teachers' responses reflected a strong traditional mindset in this area. The reform approach to learning mathematics is that success in mathematics requires students' conceptual understanding, creative reasoning, and understanding of solutions (Ayuz & Berberoglu). Some teachers also responded positively to the reform mindset, signaling a conflict of responses.

All teachers agreed that thinking creatively was prerequisite to success in mathematics. In contrast, they also agreed unanimously that thinking in a sequential and procedural manner was essential to success in learning mathematics. The contrasting approaches reflect reform attitude with the creativity perspective and traditional attitude with the sequential, procedural mindedness. The two questions regarding alignment of instruction with the textbook and alignment of assessments with the textbook should have had consistent responses from teachers but this did not occur. Some teachers who indicated that they used the textbook consistently for planning instruction responded that they used tests aligned with something other than the textbook. Also, the converse of this occurred. Some teachers who did not closely align their instruction with the textbook, aligned their tests and quizzes with the textbook. This contradictory alignment suggests the need to examine the approaches used in the classroom. Teachers can reconsider their diverse approaches to instruction and testing using their questionnaire responses as the springboard for conversations within the math department and with the system director.

Reform math instructional experts recommend using additional resources of content, pedagogy and technology, as well as authentic assessments (Guerrero, 2010; Tsai, Shen, & Tsai, 2011). Traditionally, rural teachers have relied on teaching and testing from the textbook with a minimal use of ancillaries. The reform approach to learning encourages the use of open sources online and demonstrations from media clips (Maher, C. A., Palius, Maher, J. A., Hmelo-Silver, & Sigley, 2014), student-friendly sources such as YouTube, current movies, Ted Talks, and consumer reports. The contemporary approach to motivate student engagement through interactive software in Canada has proven effective in promoting mathematics communication in the digital era (Lazarus, & Roulett, 2013). A hybrid blend of traditional and reform describes the rural teachers in the current study. This blended model is consistent with that recommended by literature (Grady, Watkins, & Montalvo, 2012). Consideration of these varied approaches can aid in consistency of instruction across the school. While instruction varies from teacher to teacher, the same strategies can still be in place in every classroom.

Results of the study encourages teachers to investigate and use their students' ACT scores in targeting those students needing motivation or remediation prior to retaking of the ACT math test. Using the PLAN test scores will enable teachers to select appropriate grouping of 10^{th} grade math students for discovery tasks and target those needing remediation or extra tutoring. Results of the study yields side benefits not intended by the original hypotheses.

One additional side benefit of the study is the research-based listing of reform strategies linked to the standards, ACT quality teacher indicators, and rural place-value indicators contributing to culturally responsive teaching. Teachers who did not describe the school as rural on their questionnaire can now recognize that the school is one of the 80% rural schools in Tennessee. The questionnaire responses reflected minimal attention given to connecting to the rural culture. Though this connection was not statistically significant as related to the ACT math subtest, it is vital to motivation and engagement of students prior to building math competencies. Teacher awareness of the culture in which students live and the potential employment opportunities beyond high school and college entices connections between math and community. Instead of the mindset demonstrated by most of the teachers that mathematics is “a vehicle to move from the rural area to aid the global economy”, teachers can adopt the mindset that students can use their mathematics to improve the local community. This latter mindset, a designated reform mindset, implies there is place value in the rural community, an important strategy for reaching rural students (Grady, Watkins, & Montalvo, 2010). The increased engagement of rural student learners through rural connectedness does not directly increase ACT math scores however it does generate interest in STEM career opportunities in the immediate community. Teachers’ awareness of community STEM career opportunities can increase the likelihood they will pass information along to students (Erdogan & Stuessy, 2015). STEM deficiencies were an underlying problem voiced early in the proposal of the study.

Recommendations for Action

Recommendations for action, based on the results of the research study, are:

- Make PLAN and ACT math subtest scores available to math teachers and encourage the use of the scores in planning interventions and lessons. (Questionnaire results reported no teacher use of these scores for planning lessons or activities.)
- Design professional development for math teachers connecting them to the rural community. Partner classes and students with community leaders and industry to allow student interaction and involvement in problem-solving.

(Questionnaire results reported no teacher used rural community connections to inform students about STEM careers elevating the place value of their rural existence.)

- Set teacher goals for maintaining and improving their individual students' ACT math performance. (Evidence of not reaching ACT benchmark of 22 in math indicate the need for specific steps toward achieving that goal.)
- Establish a teacher/instructional, supervisory committee to ensure that math curriculum content aligns with all ACT math expectations. (One of the potential obstructions to the significance of the research linking ACT with reform practices was the possible misalignment of ACT curriculum and the school curriculum.)
- Encourage teachers to do a self-assessment of their practices. Using the questionnaire as a springboard, teachers could discuss their current practices, their experiences, and their plans for implementing new strategies from the research-based items on the questionnaire.
- Examine potentialities of the other influential factors that literature suggests may obstruct optimal student outcomes. Consider home and background (Harmon & Smith, 2012), student perception of potential success (Davis, 2011), teacher knowledge of mathematics (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012, Marshall & Sorto, 2012), teacher relational interactions within instruction (Battey, 2013, Gresalfi, Barnes, & Cross, 2012), student perception of potential for success (Strayhorn, 2015), and student motivation toward school (Hardre, 2012, Hendrickson, 2012). Additional research on inner-city

youth in metro Nashville, Tennessee (Smith, Elder, Stevens, 2014) concluded that all students can aspire toward college given they possess the determination. There are opportunities for teacher impact on the degree of influence of the factors where measures of positive intervention are possible.

- Future qualitative research exploring observed teacher reform protocol can assist with identifying effective strategies. The researcher recommends the use of classroom observations coupled with student surveys to report effectiveness of reform strategies. Contrasting outcomes from rural and nonrural schools can further respond to the question regarding any differences of the two sectors.

Implications for Positive Social Change

Social change reliant on the results of the study are restricted to the immediate school until further research extends the significance. Important issues included teachers' lack of awareness of rurality of the school, lack of integration of other subjects and community career opportunities into class instruction, and the need for curriculum supportive of concepts important to college readiness. Administrative endeavors toward alleviating weaknesses will benefit from internal assessment. Teachers and students can benefit from incorporating particular strategies into instruction that were consistently missing from all teachers’ instruction.

Suggestions for further research are for a study focused on the students that incorporate the factors deemed outside of the realm of this study. Those factors of home and family background, motivation, student perception of their potential for success, and past success in mathematics could be assessed individually through a student-focused research study. This study illumated particular student factors leading to improved ACT math outcomes. This information can increase rural sensitivity and motivate a rurally responsive teaching approach. The positive social change intended by these suggested internal changes are the improved student readiness for college math and preparedness for STEM careers in the surrounding community. Small changes at one rural high school in the South leads to larger changes in the state and across the South.

Conclusion

The outcomes of the research study were inconclusive regarding the effectiveness of reform practices on rural student readiness for college math. There were no significant correlations between any of the main independent variables (level of reform instruction, teacher connectedness to the rural community, use of technology in instruction, student gender, and student choice of academy) and the dependent variable (value-added score on the ACT Math subtest). Also, there were no correlations with subordinate independent variables of student gender, student SES level, or student choice of an academy with the dependent variable of ACT math gains.

Student outcomes related to reform instructional practices did not provide sufficient evidence of positive effect of reform over traditional or a blend of reform and tradition. Teacher use of reform practices are not the main factor influencing rural student readiness for college math at this sample school. Implementation of reform strategies varied from teacher to teacher. These inconsistencies in understanding of effective implementation of any practice produced inaccurate responses to the teacher questionnaire items. Teacher self-reported practices on the questionnaire yielded conclusive evidence that teachers at the sample rural high school used a blend of traditional and reform strategies during the 2014-2015 school year. There is room for growth in the effective implementation of reform instruction.

The results of the research, though not as anticipated, provided information for teachers and administrators that enables improvements in college math readiness. Recommendations included:

- Attention to curriculum alignment
- Use of PLAN and ACT math subtest scores in instructional planning
- Cohesive efforts to connect to the rural community
- Interventions for students not meeting ACT benchmarks

These suggestions rely on current literature and motivate teachers to improve students' college math readiness.

The original hypothesis regarding the link between ACT math score and the level of reform instruction did not have sufficient evidence for rejection. The mean value-added gain for those students receiving higher levels of reform was no different from those receiving mostly traditional instruction during their 11th-grade mathematics classes. A discussion of the inherent implications and a close examination of the responses on the teachers' questionnaires revealed consistencies and inconsistencies. The two conclusions from the research are:

- Rural student outcomes are independent of the level of reform used by their teacher.
- Factors other than reform strategies of the teacher influence college math readiness scores.

A discussion of other extraneous influences supported by literature invites investigation into the effectiveness of these influences on student performance at the sample rural school. None of the self-reported responses to questionnaire constructs indicating reform or traditional teacher behavior during instruction yielded conclusive results of their effectiveness.

The secondary hypothesis regarding the influence of socioeconomics of value-added scoring on the ACT math subtest did not show significance with respect to the level of reform instruction received by the student. There was no distinguishable difference in the gains made by students of low socioeconomics and the gains made by students of higher socioeconomic status. This result agreed with findings from a recent longitudinal early childhood study. The study (Burchinal, Steinberg, Friedman, Pianta, McCartney, Crosnoe, & McLoyd, 2011) concluded that family experiences of black or white low-income children were not as predictive of success in school as the school effect. This finding increases the importance of school and the effect that teachers can have on their students.

The factor of economics may not be accurately reported for all students at the participating school, as explained earlier, due to inaccurate parental reporting of economic standing to the high school. The unreliability of reporting economically disadvantaged students made any correlation between income and student outcomes less likely to surface in the current research study. Low income may not, as determined by the early childhood study (Burchinal et al.), be as predictive of success in high school as the positive interactions between the teacher and the child. If the under-reported number of students from low SES status interfered with the accuracy in the data collection, it may be that results from prior studies prevail. Other potentially covariate variables in the study, gender and student preference of academy, demonstrated no significant correlation with student value-added gains on ACT math subtest scores.

Benefits of the study to the sample school are both informational and suggestive. Those students in the study are currently in their final year of mathematics. Evidence from the study supports an improved ACT math average for the school if students maintain their 11th-grade achievement level. Results from the study encourage awareness of rural anomalies, the potentiality for interventions, and motivation toward rural student success, especially toward STEM-preparedness. The consistencies in teacher responses to questions regarding these constructs indicated an overall need for increased awareness of potential areas of improved reform efforts. The positive momentum gained from the results of the study can leverage improved ACT Math scores for those current high school seniors. Teachers with knowledge of the value-added gains from the ACT PLAN Math subtest in 10th grade to the ACT Math subtest in the 11th grade can target deficient students for interventions. Knowledge of the potential for an overall improved average ACT Math subtest score for the school provides a powerful impetus for positive change.

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Appendix A: References for Tennessee Standards

These sites reference the two sets of mathematics standards applicable to Tennessee high school students and teachers in the school year 2014-2015. The only state-designed End of Course (EOC) mathematics courses at the high school level are Algebra I and Algebra II.

1. Tennessee Frameworks and State Standards for High School Mathematics:

    a) Tennessee State Algebra II EOC Frameworks:

    http://tn.gov/education/assessment/crt/framework_eoc_Alg_II.pdf

    b) Tennessee State Algebra II EOC Standards:

    http://tn.gov/education/assessment/crt/standard_tbl_Alg_II.pdf

2. Common Core State Standards for High School Mathematics:

    Common Core High School Standards for Mathematical Practice:

    Number & Quantity, Algebra, Functions, Modeling, Geometry, Statistics & Probability Frameworks: http://www.corestandards.org/Math/Practice/

Appendix B: Teaching Practices in High School Mathematics

CCSS Recommended High School Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make sense of structure.
8. Look for and express regularity in repeated reasoning.

Note: Excerpt from CCSS Initiative. Retrieved December 16, 2014 from http://www.corestandards.org/Math/Content/HSA/introduction/

Six Effective Practices for Rural Learners

1. Curriculum is relevant to students' lives within a supportive environment.

2. Classroom instruction is linked to the broader community.

3. Students are actively engaged with inquiry, evidence and ideas.

4. Students are challenged to develop and extend meaningful understandings

5. ICTs are exploited to enhance students' conceptual learning.

6. Assessments facilitate learning and align with course content.

(Note: Effective practices from Aldous, C. 2008. Turning the tide: Transforming science learning and teaching in rural and remote schools. *Teaching Science, 54*(3), 44-48.)

ACT Recommendations for High Quality Instruction

The ACT College Readiness Benchmarks recommend the following components for ensuring that classroom core practices meet high quality instructional standards.

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
Curriculum & Academic Guide	Staff Selection, Leadership, & Capacity Building	Instructional Tools: Programs & Strategies	Monitoring Performance & Progress	Intervention & Adjustment
Classroom Core Practices to Achieve College & Career Readiness				
Study and use the district's written curriculum to plan all instruction.	Collaborate as a primary means for improving instruction.	Use proven instructional tools to support rigorous learning for students.	Analyze and discuss student performance data.	Use targeted interventions or adjustments to address learning needs of students.

(Note: The Core Practice Framework is from the ACT CCR framework for classroom, school, and district core practices. Accessed January 20, 2015 at http://www.act.org/products/additional-products-assessments/act-core-practice-framework/)

Tennessee Ready Standards K–12

Eight Standards for Mathematical Practice, grades K – 12

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make sense of structure.
- Look for and express regularity in repeated reasoning.

Note: Specific learning objectives for each level of high school mathematics are in the TNReady Standards and testing planned for implementation in 2016.

(TN DOE, Assessments. Accessed August 26, 2015 at

http://www.tn.gov/education/article/mathematics-standards#sthash.gCWPhLOd.dpuf)

Appendix C: Teacher Questionnaire & Correlated Practices

Teacher Questionnaire

Please answer every question, responding as accurately as possible according to your instruction with 11th grade students this semester.
There are no "**right**" or "**wrong**" answers to any question.
Your Questionnaire is confidential and your responses will not be shared with anyone other than the researcher, as required by the Walden University Institutional Review Board.

	Question	Response
1	Do you instruct 11th graders in math this year? (If NO, stop here. Do not complete the questionnaire. Return it now in the postage paid envelope.)	A. Yes B. No
2	Have you received training in Tennessee Common Core Standards or Reform Math Instruction?	A. Yes B. No
3	Which best describes the school where you teach?	A. Rural Public School B. Urban Public School C. Private School
4	In a typical week of lessons, how many of the following 10 technologies are used **by students** for activities or tasks during math class? • Computer • Tablet • Interactive whiteboard • Camera • Mobile phone • Wireless communication device between teacher & student (other than cell phone) • TI-Nspire • Graphing calculator • CBL or data probes • GPS tracker	0 – 10 _________
5	In a typical week of lessons, what percentage of class time is spent on homework review? (0-100)	0 – 100 ________
6	In a typical week of lessons, what percentage of class time is spent on lecture-style presentation by the teacher? (0 - 100)	0 – 100 ________
7	In a typical week of lessons, what percent of class time is spent on teacher-guided student practice? (0 - 100)	0 – 100 ________
8	In a typical week of lessons, what percent of class time is spent on re-teaching and clarification? (0 - 100)	0 – 100 ________

9	In a typical week of lessons, what percent of class time is spent practicing and discussing questions to prepare for ACT?	0 – 100 _______
10	In a typical lesson, how often do I ask students to reason both abstractly and quantitatively?	A. 0 B. 1 or 2 times C. 3 or 4 times D. 5 or more
11	In a typical week of lessons, how often do students work in pairs or on a team?	A. 0 B. 1 C. 2 or 3 D. 4 or more
12	In a typical week, how many days do I assign mathematics homework? (0 - 5)	A. 0 B. 1 C. 2 D. 3 or more

For the next several questions, circle A, B, C, or D with response choices:

A. Daily
B. Often
C. Rarely
D. Never

13	How often do I encourage my students to use graphing calculators independently for investigating graphs, tables, data, and equations?	A	B	C	D
14	How often do I encourage my students look for and make sense of structure?	A	B	C	D
15	How often do I encourage my students to look for regularity and use algorithmic processes?	A	B	C	D
16	How often do I ask students to write equations to represent relationships?	A	B	C	D
17	How often do I require students to reflect on their thinking through writing or discourse?	A	B	C	D
18	How often do I collaborate with colleagues as a primary means for improving instruction?	A	B	C	D
19	In my math lessons, how often do I ask students to explain reasoning behind an idea?	A	B	C	D
20	In my math lessons, how often do I ask students to analyze relationships using charts, tables, or graphs?	A	B	C	D
21	In my math class, students use graphing calculators linked to digital technology such as data collection devices, data probes, computers.	A	B	C	D
22	In my math lessons, how often do I integrate other subjects such as science or history?	A	B	C	D
23	How often do I ask students to critique the reasoning of peers?	A	B	C	D
24	How often do I ask students to model with mathematics?	A	B	C	D

For the next several questions, circle A, B, C, or D with response choices: **A. Strongly Agree**
B. Agree
C. Disagree
D.Strongly Disagree

25	I use targeted interventions to address learning needs of deficient students.	A	B	C	D
26	Good performance in mathematics depends on remembering formulas and procedures.	A	B	C	D
27	Good performance in mathematics depends on thinking in a sequential and procedural manner.	A	B	C	D
28	Math is primarily an abstract subject.	A	B	C	D
29	Some students have a natural talent for mathematics and others do not.	A	B	C	D
30	To be good in mathematics, a student must understand math concepts.	A	B	C	D
31	To be good in mathematics, a student must think creatively.	A	B	C	D
32	To be good in mathematics, a student must provide reasons to support solutions.	A	B	C	D
33	Math is primarily a practical and structured guide for addressing real situations.	A	B	C	D
34	I use the textbook to plan all my instruction.	A	B	C	D
35	I study and use the system curriculum to plan all my instruction.	A	B	C	D
36	My students use calculators primarily for calculations.	A	B	C	D
37	My math tests align with student practices and tasks more than with the textbook.	A	B	C	D
38	My instruction follows the textbook almost exclusively.	A	B	C	D
39	I encourage the use of proven instructional tools to support rigorous learning for students.	A	B	C	D
40	I analyze and discuss student performance data.	A	B	C	D
41	The focus and direction of my lessons are often determined by student ideas.	A	B	C	D
42	In my math lessons, I encourage students to share alternate methods of solving a problem.	A	B	C	D
43	I encourage students to use calculators for discovery of a new concept before I present it.	A	B	C	D
44	I encourage students to use calculators for solving complex problems.	A	B	C	D
45	In my instruction of a new concept, I typically use multiple representations of graphs, equations, diagrams, or simulations.	A	B	C	D
46	My lessons are innovative and my assessments are authentic; both align with course content.	A	B	C	D
47	I develop lessons based on feedback from frequent formative assessments.	A	B	C	D
48	I use student PLAN scores to plan my math lessons or activities.	A	B	C	D
49	In my math class, I ask students to work problems which have no immediately obvious method of solution.	A	B	C	D
50	In my math class I ask students to work together to solve problems which have no immediately obvious method of solution.	A	B	C	D

51	In my math class, I often have students do a discovery activity to introduce a new concept where student exploration precedes my presentation.	A	B	C	D
52	In my math class, students work independently using multiple representations to model problems.	A	B	C	D
53	I use summative assessments as BOTH learning experiences and measures of student progress.	A	B	C	D
54	In my math lessons, I frequently use rural applications relevant to students.	A	B	C	D
55	In my math class, I provide opportunities for students to learn about math careers in the community via speakers, video, Skype, etc.	A	B	C	D
56	In my math class, I provide opportunities for students to interact with community leaders to solve community problems.	A	B	C	D
57	I involve my students in community activities and/or service projects.	A	B	C	D
58	I incorporate student out-of-school experiences into meaningful classroom activities.	A	B	C	D
59	I know about and understand the rural culture, history, and economics of the community in which I teach.	A	B	C	D
60	I view math education as a vehicle for my students to move from the rural area to aid the global economy.	A	B	C	D

Return your completed questionnaire in the stamped, addressed envelope provided.

Note: This teacher questionnaire is a consolidated and modified version of the survey used by Akyuz & Berberoglu (2010) and the RTOP questionnaire by Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith (2010). Modifications include addition of ACT and CCSS practices, and research-based effective practices in mathematics instruction.

Item Analysis of Questionnaire

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
1	Teacher of 11th graders	Teacher Inquiry	NA	Teacher Characteristics
2	Teacher Training	Teacher Inquiry	NA	Teacher Characteristics
3	Teacher Perception of Rural Community	Researcher Driven Construct	Rural Place Value	Rural Practice 1 (Aldous, 2008) Rural Place-Value (Barter, 2014; Leonard, Russell, Hobbs, & Buchanan, 2013; Howell, Showalter, Klein, Sturgill, & Smith, 2013)
4	Use of Other Technologies	Index Variable	Constructivist Practice Technology	CCSS Practice 5; ACT Theme 3; Rural Practice 5 (Aldous, 2008)
5	Homework Review	Allocation of Class Time	Traditional Practice	Teacher Conceptions (Akyuz & Berberoglu, 2010)
6	Lecture Style	Allocation of Class Time	Traditional Practice	Teacher Conceptions (Akyuz & Berberoglu, 2010)
7	Teacher-Guided Practice	Allocation of Class Time	Traditional Practice	Teacher Conceptions (Akyuz & Berberoglu, 2010)
8	Re-teaching	Allocation of Class Time	Traditional Practice	Teacher Conceptions (Akyuz & Berberoglu, 2010); ACT Theme 5
9	ACT Practice	CCR Test Prep	Traditional Practice	CCSS Practice 8; ACT Theme 5

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
10	Student express abstract problem quantitatively	Index Variable	Constructivist Practice Reasoning	CCSS Practice 2; Rural Practice 4 (Aldous, 2008)
11	Student Pairs/Team tasks	Index Variable	Constructivist Practice Reasoning & Problem Solving	Rural Practices 3 & 4 (Aldous, 2008)
12	Homework	Researcher Driven Construct	Traditional Practice Homework	Teacher Conceptions (Akyuz & Berberoglu, 2010)
13	Independent Use of Calculators for Investigations	Index Variable	Constructivist Practice Technology	CCSS Practice 5; Rural Practice 3; ACT Theme 3
14	Students Look For Structure of Problem	Index Variable	Constructivist Practice Structure in Solutions	CCSS Practice 7
15	Students Look for Regularity & Use Algorithmic Processes	Index Variable	Traditional Practice Regularity; Algorithms	CCSS Practice 8
16	Students Write Equations to Represent Relationships	Index Variable	Traditional Practice Reasoning	CCSS Practices 2 & 4
17	Students Reflect on Thinking through Writing or Discourse	Index Variable	Constructivist Practice Reasoning	CCSS Practices 1, 2, & 3; Rural Practice 3

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
18	Collaboration with Colleagues	Index Variable	Constructivist Practice Leadership & Capacity	ACT Theme 2
19	Student Explain Reasoning	Index Variable	Constructivist Practice Reasoning & Problem Solving	CCSS Practice 3 Rural Practices 3 & 4 (Aldous, 2008)
20	Students Analyze Relationships using charts, tables, or graphs	Index Variable	Constructivist Practice Reasoning & Problem Solving	CCSS Practice 4; Rural Practice 3 (Aldous, 2008)
21	Use of Calculators linked to Digital Technology	Index Variable	Constructivist Practice Technology	CCSS Practice 5; ACT Theme 3; Rural Practice 5 (Aldous, 2008)
22	Teacher Integrates other subjects & Math	Researcher Driven Construct	Constructivist Practice Integration of Subjects	Rural Practice 2 (Aldous, 2008) Rural Place-Value (Jong et al., 2010)
23	Students Critique Peer Reasoning	Index Variable	Constructivist Practice Reasoning	CCSS Practice 3; Rural Practice 3 (Aldous, 2008)
24	Students Model a Real Problem using Mathematics	Index Variable	Constructivist Practice Multiple Rep.	CCSS Practice 4; Rural Practices 2 & 4 (Aldous, 2008)
25	Use of Targeted Interventions	Index Variable	Constructivist Practice Interventions	ACT Theme 5; Cramer & Mokher, 2015).
26	Math Performance depends on memorization of formulas, etc.	Researcher Driven Construct	Traditional Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010)

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
27	Math Performance depends on thinking sequentially	Researcher Driven Construct	Traditional Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010); CCSS Practice 7
28	Math is primarily an abstract subject	Researcher Driven Construct	Traditional Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010)
29	Math is a talent; not all students have it	Researcher Driven Construct	Traditional Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010)
30	To be good in mathematics, a student must understand math concepts	Researcher Driven Construct	Constructivist Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010); CCSS Practice 8
31	Math success depends on creativity	Researcher Driven Construct	Constructivist Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010)
32	Math success depends on ability to support solutions with reasoning	Researcher Driven Construct	Constructivist Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010); CCSS Practice 3; Rural Practice 3
33	Math is a practical & structured guide for addressing real situations	Researcher Driven Construct	Constructivist Approach	Teacher Conceptions (Akyuz & Berberoglu, 2010); CCSS Practice 7
34	Use of Textbook & Adopted Curriculum	Index Variable	Traditional Practice Curriculum	ACT Theme 1
35	Use of System Adopted Curriculum	Index Variable	Traditional Practice Curriculum	ACT Theme 1

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
36	Use Calculators for calculations	Index Variable	Traditional Practice Technology	Teacher Conceptions (Akyuz & Berberoglu, 2010)
37	Teacher Aligns Tests with student practices/tasks	Index Variable	Traditional Practice Summative Assessments	Rural Practice 6 (Aldous, 2008)
38	Instruction is Textbook-driven	Index Variable	Traditional Practice Curriculum	Teacher Conceptions (Akyuz & Berberoglu, 2010); ACT Theme 1
39	Use of Tools to Promote Rigor	Index Variable	Constructivist Practice Use of Tools	ACT Theme 3; Rural Practice 5; CCSS Practice 5
40	Discussion of Student Performance & Improvement Strategies	Index Variable	Constructivist Practice Interventions	ACT Theme 4
41	Focus & Direction of Lesson often determined by student ideas	Index Variable	Constructivist Practice Reasoning & Problem Solving	Constructivist Lesson Design (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010)
42	Students Share Alternate Original Solutions	Index Variable	Constructivist Practice Reasoning & Problem Solving	Rural Practice 3 (Aldous, 2008): Communicative Interactions (Jong et al., 2010)
43	Use Calculators for Discovery of New Concept	Index Variable	Constructivist Practice Technology	CCSS Practice 5 ACT Theme 3 Rural Practice 5 (Aldous, 2008)

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
44	Use Calculators for Solving Complex Problems	Index Variable	Constructivist Practice Technology	CCSS Practice 5 ACT Theme 3 Rural Practice 5 (Aldous, 2008)
45	Teacher Uses Multiple Representations in Instruction	Researcher Driven Construct	Constructivist Practice Multiple Rep.	CCSS Practice 4 (Akyuz & Berberogluz, 2010; Jong, Pedulla, Reagan, Salomon-Fernandez & Cochran-Smith, 2010)
46	Authentic assessments aligned with course content	Index Variable	Constructivist Practice Curriculum	Rural Practice 6 (Aldous, 2008); (Akyuz & Berberogluz, 2010; Barter, 2014)
47	Teacher Develops Lesson Plans based on Frequent Formative Assessments	Index Variable	Constructivist Practice Formative Assessments	ACT Theme 5; (Akyuz, Dixon, & Stephan, 2013)
48	Use PLAN scores to plan lessons	Index Variable	Constructivist Practice Formative Assessments	ACT Theme 5
49	Challenge students to work independently to solve problems.	Index Variable	Constructivist Practice Reasoning & Problem Solving	CCSS Practice 7; (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010)
50	Challenge students to work together to solve problems	Index Variable	Constructivist Practice Interactively	CCSS Practice 7; (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010)
51	Discovery Activity to Introduce New Concept (explore prior to instruction)	Index Variable	Constructivist Practice Reasoning & Problem Solving	CCSS Practice 7; (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010)

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
52	Students Use Multiple Representations to model problems	Index Variable	Constructivist Practice Multiple Rep.	CCSS Practices 1 & 4; Rural Practice 3 (Aldous, 2008); (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010)
53	Teacher Uses Summative Assessments as both learning experience & progress measure	Index Variable	Constructivist Practice Summative Assessments	Rural Practice 6 (Aldous, 2008); (Akyuz & Berberoglu, 2010)
54	Teacher frequently uses rural applications relevant to students	Researcher Driven Construct	Rural Place-Value	Rural Practice 1 (Aldous, 2008) Rural Place-Value (Barter, 2014; Leonard, Russell, Hobbs, & Buchanan, 2013; Howell, Showalter, Klein, Sturgill, & Smith, 2013)
55	Teacher provides opportunities to observe math career opportunities in community	Researcher Driven Construct	Rural Place-Value	Rural Practice 2 (Aldous, 2008); Rural Place-Value (Howell, Showalter, Klein, Sturgill, & Smith, 2013)
56	Teacher provides opportunities to solve community problems	Researcher Driven Construct	Rural Place-Value	Rural Practice 2 (Aldous, 2008); Rural Place-Value (Howley, Showalter, Klein, Sturgill, & Smith, 2013)
57	Teacher involves students in Community Service Projects	Researcher Driven Construct	Rural Place-Value	Rural Practice 2 (Aldous, 2008); Rural Place-Value (Howley, Showalter,

Q	Question Content	Construct	Reform, Constructivist or Traditional	Correlation(s) CCSS, ACT, Research-Based Practices
				Klein, Sturgill, & Smith, 2013)
58	Teacher incorporates student out-of-school experiences into meaningful classroom activities	Researcher Driven Construct	Rural Place-Value	Rural Practices 1 & 2 (Aldous, 2008); Place-Based Math in Rural Classrooms (Leonard, Russell, Hobbs, & Buchanan, 2013; Avery, 2013; Barter, 2014)
59	Teacher understands local rural culture, history & economics	Researcher Driven Construct	Rural Place-Value	Place-Based Math in Rural Classrooms (Leonard, Russell, Hobbs, & Buchanan, 2013; Avery, 2013; Barter, 2014)
60	Teacher Views Student Education as Vehicle to move from rural to global OR vice-versa	Researcher Driven Construct	Rural Place-Value	Place-Based Math in Rural Classrooms (Leonard, Russell, Hobbs, & Buchanan, 2013; Avery, 2013; Barter, 2014)

Appendix D: Cover Letter to Administrators

Date

Director of Schools & Principal

XXXXXX County, Tennessee

Dear (Administrator's Name),

Your school system is under consideration for a research project regarding high school mathematics instruction and student college readiness. The research proposes to assist rural high schools in identification of effective practices promoting college academic readiness for rural learners.

Who will participate?

Participants will be all 11th grade mathematics teachers and their 11th grade students enrolled in a mathematics course during the 2015 spring term. Cooperation and assistance from the guidance testing coordinator at the high school will also be necessary.

What will be required of Participants?

Each 11th grade mathematics teacher who is teaching 11th graders this term will be eligible to participate. Each participating teacher will be required to complete online teacher questionnaires to determine the extent of reform mathematics instruction implemented in the mathematics classroom. Questionnaires would take 20 minutes or less to complete. Student data would include mathematics subtest scores on the PLAN, EXPLORE, and ACT and demographic data. The school coordinator will provide student data including test scores, current mathematics teacher, and student demographics. The coordinator will be responsible for removing student identification from the data prior to release. Each participating teacher will be given an informed consent form to indicate willingness to participate.

Purpose of the research:

The research will relate math instructional practices to student performance on the college success predictive test, ACT. Only the ACT mathematics subtest scores will be needed. Mathematics instruction is in transition from traditional to reform instruction. Though all Tennessee teachers received Common Core State Standards training, teacher implementation varies from full reform, to traditional, to a blend of the two.

Implementation may depend upon the teacher's interpretation of the training, availability of technology, understanding of reform theories, or individual teacher evaluation of what is best for their students. Rural students have specific needs that may account for the gap between rural and non-rural student outcomes. This research may enable educators to identify some of those needs and target effective practices for rural learners.

Confidentiality of the Research Results:

The results of the research will be confidential and shared only with the researcher, the institution of higher education. The names of all participants will be confidential and will not be released to any other party. Replacement names and coded numbers will conceal the identities in the research study. Upon request, a summary copy of the research findings will be supplied to the school and to each participating teacher. Again, complete anonymity of teachers and students will be guaranteed for each participant.

Benefits of the research:

The untapped resource of mathematical talent in rural areas is important to the progress within the rural community as well as to the economic future of our nation. The results of the research may enable informed selection of curriculum, identification of teacher training or technology needed, and may improve teacher awareness of effective practices in mathematics instruction. All of these results may lead to improved college readiness in mathematics and may lead to improved Math ACT scores.

How does my system join the research?

Please respond via email (luajean.bryan@waldenu.edu) to indicate your interest or if you have further questions. Your response is needed within three days. Thanks for your interest in this research.

Sincerely,

Luajean Bryan

Luajean Bryan

B.S. Mathematics, Tennessee Wesleyan College
Master of Mathematics, UT Knoxville
Ph.D. Doctoral Candidate at Walden University