Instructional Strategies and Rigor: Private School Administrator and Teacher Perspectives on Improving Minnesota’s College Mathematic Readiness

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INSTRUCTIONAL STRATEGIES AND RIGOR: PRIVATE SCHOOL ADMINISTRATOR AND TEACHER PERSPECTIVES ON IMPROVING MINNESOTA’S COLLEGE MATHEMATIC READINESS

A Dissertation

By

Nichelle M. Guillaume

Submitted to the College of Winona State University in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

May 2021
This dissertation, submitted by Nichelle Guillaume in partial fulfillment of the requirements for the degree of Doctor of Education at Winona State University, Winona, Minnesota, is hereby approved by the committee under which the work has been completed.

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ABSTRACT

Instructional Strategies and Rigor: Private School Administrator and Teacher Perspectives on Improving Minnesota’s College Mathematic Readiness (May 2021)

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This qualitative study explored private high school administrator and teacher perspectives on instructional strategies and rigor to improve Minnesota’s college mathematic readiness. Data collection sources for the study included individual interviews, focus groups, and document review. The study produced four emergent themes from the data collected in the individual interviews and focus groups: (a) Importance of Productive Struggle in Mathematic Instruction; (b) Necessary Balance of Mathematical Conceptual Understanding with Skill Acquisition; (c) Connection of Continuous Assessment to Mathematic Content Mastery and (d) Variation and Customization of Mathematical Instructional Practices. Findings from the study concluded that at the private school of study administrators set forth specific academic requirements necessary to implement rigor and promote reaching college readiness, and the teachers create the instructional strategies to meet these requirements to prepare students for college mathematics. Recommendations for research include a study of the same phenomenon in a larger school, a comparative study of private and public schools and the instructional strategies used to support college readiness, and the perspectives of college mathematic faculty on the readiness of entering college freshmen.
DEDICATION

I dedicate this work to my two children, Zaida and Zeppelin, and my parents, Myron and Kimberly. Zaida and Zeppelin, thank you for all the hugs and giggles to get me through when I felt defeated. Each day I looked in your eyes I knew quitting was not an option, this was all for you two. It is my hope that as you both grow up, you will develop a love for education and learn that you can accomplish and achieve anything. You have both made me stronger and more motivated than I could have ever imagined. I love you both to the moon and back.

Mom and Dad, thank you for everything. I owe all my successes and accomplishments to you two. Through all the schooling, successes, and struggles, you were always there with loving arms and motivating words. You taught me to never give up, work hard, and always go above and beyond. You shaped me to be the woman I am today, and I could not be more blessed to have had you two by my side the entire time. I love you both so much.
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Chapter 1

INTRODUCTION

College readiness remains an issue in the United States (U.S.) as the percentage of students who meet mathematic benchmarks plummets to the lowest point in 15 years (American College Test, 2019). This decline in mathematic performance presents a national concern in the United States (Atuahene & Russell, 2016). In 2019, 1.8 million students took the American College Test (ACT); of those, only 37 percent met three of the four main ACT College Readiness Benchmarks being English, Reading, Math, and Science, while 36 percent failed the exams (ACT, 2019). Specifically, 61 percent of students nationally do not meet the ACT Math College Readiness Benchmark (ACT, 2019). Focusing on Minnesota, 48 percent of students do not meet the ACT Math Benchmark, indicating that Minnesota students are not adequately prepared for college mathematic courses (ACT, 2019). Low mathematic achievement, which threatens college-level mathematics success, calls for intervention, and a review of instructional strategies (Robinson, 2020). There is encouragement of teachers to increase the rigor such as that in private schools in the mathematics classrooms; unfortunately, studies on instructional strategies to complete this request are absent in today’s educational system (Blackburn, 2018; Hodara, 2013).

In the U.S. high school mathematics teachers struggle with the challenges of meeting student needs through different strategies (Howard, 2018). Preparing students for higher education through diverse teaching methods is essential (Howard, 2018). In Minnesota, in 2018, the startling data that roughly 50% of students entering colleges and universities did not meet math standards solidifies that student’s preparation for college coursework is lacking (ACT, 2019). High school students are completing an unlimited number of high-level, challenging
mathematic courses, and maintaining a high GPA (Venezia & Jaeger, 2013). However, according to the National Assessment of Educational Progress (NAEP), student mathematic scores are the same as those in 1973 (Craft & Capraro, 2017). Several schools claim to use accuracy in coursework taught to students. Consequently, that rigor still does not accurately prepare students for future post-graduate education (Craft & Capraro, 2017). With changing state standards, a critical instructional shift across educational environments needs consideration (Marzano & Toth, 2014). Each year, more college professors and mathematicians who work in higher education criticize the inadequate mathematic preparation of first-year students (Kamin, 2016). Mathematics should not be a subject that solely includes rules and memorization; focus on logical reasoning, problem-solving skills, and analysis is critical (Kamin, 2016). An exploration of objectivity in schools that are accurately preparing students for college may provide insights into beneficial mathematical instructional strategies (Howard, 2018).

School systems have a national reputation for a “lack of focus on precise academic standards and their effects on academic achievement” (Sims, 2019, p. 10). Students often leave high school without adequate preparation in mathematics due to lack of rigor in the curriculum (Hodara, 2013). Underprepared students, unfortunately, encounter obstacles to college mathematic success as well as college completion (Hodara, 2013). The transition from high school to college coursework is problematic, with over half of students failing to meet college-readiness standards in mathematics (Schudde & Keisler, 2019). The reduction of mathematic preparedness in first-year students results in required remedial courses to catch students back up to the needed level of knowledge (Cruce & Mattern, 2020). Remedial courses not only hold students back, as making progress toward a degree is contingent upon successful remedial course completion but are also financially draining (Boatman & Long, 2018). School systems spend
seven billion yearly on remedial coursework in attempts to prepare students for higher-level courses; however, this is essentially a repeat of high school coursework (Ngo, 2020). Repeating secondary classes would not be necessary if schools had adequately prepared students (Boatman & Long, 2018). To succeed, high schools need to focus on challenging mathematic courses to prepare students for future college and career paths (Cogan et al., 2019).

The Minnesota Department of Education (MDE) states for the fifth consecutive year, mathematic scores statewide fell, leaving only 54 percent of students testing proficient or better, down five percent since 2016 (MDE, 2019). While Minnesota high school graduates still perform higher than national averages in mathematic scores, they still lack the mathematical skills for college readiness (ACT, 2019). Among Minnesota’s 2019 high school graduates, only 43 percent met three of the four main College Readiness Benchmarks, focusing solely on mathematics, just 52 percent of graduates met the mathematics benchmark (ACT, 2019). While the goal of high schools across the state of Minnesota is to prepare students for college and career choices post-graduation, the limited data present to support this is concerning (ACT, 2019).

Every year, thousands of post-secondary students enroll in college without the necessary skills needed for academic success (Bonner & Thomas, 2017). Specifically, even though the midwestern state holds the highest average composite score in the nation, high school graduates are still not prepared for college-level coursework (ACT, 2019). Low mathematical proficiency leads to inadequately prepared students entering college, negatively affecting first-year college students (Lewis, 2019). Preparing students for higher-level coursework is even more vital today, as college enrollment rates increase (NCES, 2019). Thus, instructional strategies in secondary mathematics classrooms need intervention (Lewis, 2019).
Instructional rigor is a significant factor in effective instruction in the classroom (Blackburn, 2017). A major challenge facing those students seeking a post-secondary degree is a shortfall of academic preparedness for college-level coursework, particularly, college-level mathematics (Hodara, 2013). Enrolling in the correct mathematical courses in high school, will increase the likelihood of success (ACT, 2019). As high school begins, students who are struggling in mathematics need supportive instructional strategies, not placement in low-level mathematic classes, and shuffled through grade levels (ACT, 2019). Low-level mathematic classes result in an increased number of students needing remedial coursework in college, making completion of a bachelor’s degree a problematic task (Riggleman, 2017). In 2019, the National Center for Education Statistics (NCES) reported that 40% of undergraduate college students drop out and never graduate, while 30% of first-year college students drop out before the second year in college (NCES, 2019).

Increasing classroom activities and instructional strategies to promote student engagement is an essential part of education today (Craft & Capraro, 2017). Rigor is dependent on the intensity and difficulty of the mathematics courses, alignment to college courses, quality of instruction, curriculum, and student’s effort and engagement (Allen et al., 2017). Statistics show that there is a lack of hardship in today’s educational system, especially in STEM courses (Sahin & Top, 2015). Ultimately the more consistency, the more student engagement, which encourages critical thinking skills valuable later in college and career pathways (Craft & Capraro, 2017). If the requirement is that students learn at high levels in high schools, the difficulty will match that of college, preparing students for the necessary level of coursework in college (Craft & Capraro, 2017). Accordingly, the chances of a student succeeding in college increase (Craft & Capraro, 2017).
Locally, the public and private school districts encourage the use of nationally recognized college entrance exams such as the ACT to inform students, parents, and staff on student progress to national college and career readiness standards (School of Study, 2019). The private-school district of study prides itself on being a four-year college-preparatory school (School of Study, 2019). At the school district, 100% of students graduate and enter four-year, two-year, or military pathways (School of Study, 2019). Fewer students than those of public schools need to take remedial coursework upon the first year at college (Uretsky et al., 2019). The ACT scores at the school of study are significantly higher than those of area public schools as well as state and national levels (School of Study, 2019). In direct comparison, the national ACT score is 20.6, the state average is 21.3, the public-school average is 22, and the private school district tops out at 25.3. Comparing the schools, the private school graduates 100% of students, including a diverse range of ethnicities ranging from white, Asian, Black, Chinese, and Hispanic. This 100% graduation rate among the minorities places this private school district above the national and state graduation rates for these minority students.

The challenging curriculum offered by the school promotes college readiness through high academic standards (School of Study, 2019), as follows, producing more academically motivated, college-ready post-graduates. Challenging curriculum varies across classrooms, which is influenced by student engagement (Allen et al., 2017). Stakeholders expect that high-level courses such as Advanced Placement (AP) courses and honors courses have a high-level difficulty; however, classification of the classes as high-level classes does not assure implementation (Allen et al., 2017). Educators frequently engage in discussions regarding attempts to measure classroom toughness (Hodara, 2013). High school grade point average, and weighted or unweighted grades are often key components that high schools consider for college
admission; however, this is often a false indicator of college readiness (Allen et al., 2017). Hence, education professionals exhibit interest in ways to measure classroom difficulty as researchers confirm that solid measurements are better indicators of academic preparedness (Mattern & Wyatt, 2012). Along with reforms to improve mathematic curriculum, studies attempt to measure academic influence and the effects on first-year college students (Mattern & Wyatt, 2012). The academic rigor index (ARI) is a method to relate high school coursework to the first-year college student grade point average (GPA) (Wyatt et al., 2011).

For mathematics, the relationship between courses taken in high school and how successful students are in first-year college educational experience is an area of inquiry (Allen & Radunzel, 2017). Further research may determine if improving the ARI process would be of benefit, as it does not appear to be a complete, reliable procedure with its scoring methods to indicate levels of consistency (Beatty et al., 2012). The knowledge of American high school students and the capabilities in mathematical classrooms have barely changed over thirty years and have not changed at all in the last fifteen years (Edmunds et al., 2017). Many students report an absence of college preparedness as college coursework begins (Edmunds et al., 2017). First-year college students more often express frustrations and inadequate preparation experienced in high school environments (Edmunds et al., 2017). Due to the importance and emphasis of challenge in high school curriculum, it is crucial to study and analyze classrooms that have been successful at implementing rigor through strategic meaningful content (Cobb, 2018). To provide insights on mathematical instruction, studies are necessary to examine these strategies (Hodara, 2013).
Purpose of the Study

The purpose of the phenomenological study was to explore the perspectives of secondary teachers and administrators on best practices in mathematical instructional strategies and the role rigor plays in college readiness.

Statement of the Problem

The United States emphasizes the importance of finishing high school and being mathematically literate to enter college (Cogan, Schmidt & Guo, 2019). Minnesota strives to reach a statewide graduation rate of 90% by 2025 with no subgroup below 85% (MDE, 2020). The problem is that limited research is present on the implementation of meaningful instructional strategies in high school classrooms to achieve these goals (Thompson et al., 2016). Research has asserted that school systems are known nationally for a “lack of focus on rigorous academic standards and their effects on academic achievement” (Sims, 2019, p. 10).

In agreement, stakeholders, policymakers, and educators voice concerns yearly regarding the college readiness of students leaving high school and the process to assure the mastery of necessary skills and knowledge to succeed in post-secondary options (Edmunds et al., 2017). Research shows a link between student achievement and strategic classroom instruction (Allen, Mattern & Ndum, 2019). Nonetheless, studying current instructional strategies in intense high schools allows insight to use instructional strategies promoting college readiness (Kim, 2018). As follows, the need to examine the implementation of demanding content in the curriculum is essential as students remain to be unprepared to take on undergraduate study (ACT, 2019). The school district of study will provide an insight to the instructional curriculum, rigor, and standards required to assist in continually preparing students who score above the national and
state ACT averages, graduate 100% of students, and academically prepare students for post-secondary coursework and success.

**Background of the Problem**

Improving the academic experience in high school courses prepares students for the high demands of college and future careers is a discussion among policymakers (Fletcher et al., 2018; Kurlaender & Howell, 2012). The call for curriculum reform began in the 1980s, when the push for an increase in the academic rigor of high school courses, especially mathematics, became popular in literature (Kurlaender & Howell, 2012). The National Council of Teachers of Mathematics (NCTM) released an academic plan called An Agenda for Action, in 1980 as well, calling for new directions in mathematics coursework (Klein, 2003). The agenda also asked educators and college professors to reevaluate mathematics teaching styles, asking teachers to implement a variety of strategies, activities, and various teaching methods (Klein, 2003). In the recent decades, researchers have explored the effects of high school curriculum on college success (Kurlaender & Howell, 2012). With increased attention in school environments indicating future college success, it is the task of school systems to assure strenuous activities take place (Morgan et al., 2018).

The creation of the Department of Education in 1979 paved the way for several educational reforms to take place with the intention to promote educational excellence and student achievement in classrooms across the nation (Gardner, 1983; Klein, 2003). The first significant reform in 1983 was a report titled A Nation at Risk (NAR) (National Commission on Excellence in Education, 1983). NAR stated that student achievement in the United States was declining and called for an increase in academic rigor in high schools (Gardner, 1983). Ultimately, NAR created high school curriculum that required four years of English, three years
of mathematics, science, and social studies, and two years of foreign language (Kurlaender & Howell, 2012). Successful completion of the core courses over the four years of high school labeled students as prepared for college courses and academics (Kurlaender & Howell, 2012).

Along with NAR and the NCTM, in 1989, the development of national mathematics standards sought to help minimalize the gap in mathematics knowledge (Klein, 2003). A strong focus on necessary mathematic skills, which lead to essential standards is necessary (Crosswhite et al., 1989). However, while the standards focused on what American children should know, there is no input regarding how to assist teachers in planning meaningful coursework that meets standards (Klein, 2003). From this point on, the prominent discussion across the nation focused on the great need for a mathematical curriculum reform (Askey, 2001). Teachers in high school environments acquired various instructional strategies and resources; however, research did not support these instructional changes (Bosse, 1995).

Post NAR, the nation’s governors adopted the National Education Goals that set a plan for the next ten years, eight objectives to accomplish by the year 2000 (Doyle, 1992). The eight targets placed an emphasis that strived for U.S. students to be first in the world in mathematics as students fell below those of international students (Ravitch, 1996). The call for students to score highly in mathematics sparked the term “math wars,” which were composed of heated controversies regarding the future of curriculum of mathematics in U.S. school systems (Ballantyne, 2019). Timing of this was profound, as the nation called for an increase in the level of mathematics education provided in the U.S. (Klein, 2003).

By 1997, most state governors adopted mathematics standards in attempts to guide mathematics learning from a basic level of comprehension to advanced (Klein, 2003). The National Science Foundation (NSF) discussed characteristics of classroom standards-based
education (Rochelle et al., 2008). Mathematic instruction consisting of lectures and note-taking was not an ideal method for success as the NSF stated learning by doing is more effective than passive methods (Klein, 2003). Educational leaders wanted more focus on learning methods such as problem-solving skills, not just memorization (Wagner, 2008). Furthermore, research did not support the NCTM standards, which in turn caused the standards to receive criticism from parents, educators, and scholars (Klein, 2003). In 1999, the U.S. Department of Education recommended a list of mathematic books which received sharp criticism from mathematicians and angered educators due to the content and expectations within the books (Schoenfeld, 2004). Thus, the mathematic wars continued as significant input on proper mathematical instructional strategies and curriculum was not available (Schonefeld, 2004).

During the mathematic wars, a plethora of resources circulated in attempts to finalize a viable mathematic curriculum and decide proper mathematical instructional strategies (Haji, 2019). In 2000, The NCTM released the Principles and Standards for School Mathematics (PSSM), a more stable version than the 1989 standards (Haji, 2019). By 2006, the struggle of the mathematic wars leads to the creation of the National Mathematics Advisory Panel (NMAP) (Haji, 2019). The NMAP consulted research for decisions regarding mathematic instruction in attempts to alleviate criticism and provide reasoning for mathematical reform (Roschelle et al., 2008). Thus, deep mathematic instruction continues to be a common debate in conversations regarding college readiness (Hodara, 2013).

Assessing college readiness is more prominent now than in the past ten years, since each year the number of students taking nationally recognized exams increases (ACT, 2019). The push for college readiness comes from the educational reforms No Child Left Behind Act in
2002 and the replacement; Every Student Succeeds Act in 2015 (Early et al., 2014). While these two acts attempted to take education in the right direction post-mathemetic wars, the focus then shifted from mathematics instruction to general student learning, leaving mathematic-specific reforms in the past and focusing on student success overall, not solely in one subject (Haji, 2019). Nonetheless, one thing remains, specific instructional strategies increase instructional quality (Early et al., 2014).

Rigor is not solely for high level courses, different forms exist and are able to be adapted to fit classroom needs (Allen et al., 2019). Most recently, in 2017, the NCTM released a new mission statement advocating for a high-quality mathematics teaching and learning environment for all (Celedon-Pattichis et al., 2018). The new mission emphasizes focusing on systemic change, which requires all students held to high academic standards in mathematics, even if the students are not in the highest level of mathematics courses offered (Celedon-Pattichis et al., 2018). The goal is to challenge all students equally, increasing teacher preparedness to emphasize adversity even in lower classes (Celedon-Pattichis et al., 2018).

Instructional approaches are directly related to mathematical success (Ansari & Lyons, 2016). Implementing diverse mathematical approaches are effective in preparing students for post-secondary coursework (Ansari & Lyons, 2016). Past educational reforms, standards, and textbooks provide minimal educational impacts compared to the effect’s rigor has on student readiness (Edmunds et al., 2017). Engaging students in higher-level thinking promotes the learning of complex and rich skills, ones not gained through steady teacher-led learning (Edmunds et al., 2017). However, minimal research exits indicating how instructors use diverse curriculum strategies in mathematics classrooms (Hodara, 2013). While students continue to
meet high school graduation requirements, students continue to be underprepared for college-level courses (Pierson, 2015).

**Research Questions**

To attain the purpose of this study, the researcher will explore the following research questions:

- **RQ1:** How do administrators and teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?
- **RQ2:** How do administrators and mathematic teachers implement and encourage rigor in classroom instruction?
- **RQ3:** What are the foundational concepts that administrators and mathematic teachers use to assess college readiness of high school students?

**Theoretical Framework**

This study was guided by a theoretical framework supporting crucial instructional strategies in attempts to prepare students for post-graduate coursework. The overarching theory guiding this research study is Merrill’s (2002) First Principles of Instruction Theory which identifies five foundational principles of instruction used to increase student learning when applied. This theory highlighted specific content implementation by stating that instruction should include five principles; task and problem-centered learning, activation, demonstration, application, and integration (Gardner, 2011). Investigating how mathematics teachers use these five principles in curriculum and classrooms provided the researcher with an idea of the high-quality instruction provided at the private school of study.

Bruner’s Spiral Curriculum Theory (1960) provided further support. This theory stated that complex topics, such as those discussed in high school mathematics courses, can be taught
to any child at any stage of development if it is structured and presented correctly (Bruner, 2009). Bruner’s Spiral Curriculum Theory (1960) described curriculum as a direct impact on learning and must continually cycle and recycle information, hence the name spiral curriculum (Jiang & Perkins, 2013). How the content is communicated, structured, and presented has meaningful effects on the learning process and understanding (Brighton, 2019).

Likewise, Folk Belief Theory (2014) offered additional reinforcement. Folk Belief Theory (2014) suggests that educators direct a more strategic curriculum to high-advantage students, such as those in a private high school environment. This theory seeks to assist the study in the idea that private high schools have high academic standards as compared to public schools (Torff, 2014). Folk Belief is the primary cause for the achievement gap among high schools as private high school teachers are known to implement a dense curriculum where public schools teach at lower levels (Torff, 2014).

**Definition of Key Terms**

This inquiry addressed issues relating to mathematical instructional strategies and the effects of rigor on college readiness. The researcher used the identified definitions for the following terms:

**Academic Success:** Academic success is defined as the ability to maintain the appropriate GPA for successful completion of the schooling of interest (Schoepp & Garinger, 2016).

**ACT:** A measure of students’ academic abilities, achievement, and college readiness through curriculum-based tests in the categories of English, Mathematics, Reading, and Science (ACT, 2019).
**ACT College Readiness Benchmarks:** The ACT College Readiness Benchmarks are the minimum ACT scores required for students to have a high probability of success in credit-bearing college courses—English Composition, social sciences courses, College Algebra, or Biology. English, science, mathematics, and reading are the four main benchmarks, additionally, science, technology, engineering, and mathematics (STEM) scores are combined to create a STEM benchmark, and English and language arts (ELA) scores are combined to create an ELA benchmark (ACT, 2019).

**College Readiness:** College readiness is defined as being prepared with the necessary learning skills and knowledge to succeed in first-year college general education courses, which lead to undergraduate degrees (Martinez et al., 2017).

**Higher Education:** Higher education is defined as any method of education post-high school graduation; this involves four-year colleges, two-year colleges, institutes of technology, and military education (Mixon & Hsing, 1994).

**Instructional Strategies:** Instructional strategies are defined as the various methods, activities, and techniques educators use to engaged and help students achieve the desired learning objectives outlined in the classroom (Wolfe, 2010).

**Mathematic Readiness:** Mathematic readiness is defined as the degree to which a student is predicted to succeed in college-level mathematic courses post high school graduation (Corbishley & Truxaw, 2010).

**NCTM Standards:** The NCTM Standards are defined as the mathematical understanding, knowledge, and skills that students should know throughout the provided education. At the point of graduation, five content areas should be mastered; those content areas
are as follows: Number and Operations, Algebra, Geometry, Measurement, Data Analysis, and Probability (Kosko et al., 2017).

**Preparatory Courses:** Preparatory courses are defined as any honors, Advanced Placement (AP), or high-level courses offered in the high schools which key goal is to prepare students for college coursework (Moore, 2019).

**Remedial Courses:** Remedial courses are defined as developmental courses that provide underprepared first-year students with the knowledge and skills needed to be successful in undergraduate classes (Sgobbi, 2019).

**Rigor:** Rigor is defined as an academic challenge that supports meaningful content while utilizing high order thinking skills to promote learning and growth (Keller, 2018; Wyse & Soneral, 2018).

**Rigorous Instruction:** Rigorous instruction is defined as thorough, intensive, precise, and meaningful instruction that takes place in a classroom setting to prepare students for future schooling opportunities (McAlister, 2016).

**Methodology**

A qualitative design was ideal for this study, as its purpose is exploring phenomena in the teaching experiences of high school mathematic teachers. This research study used the qualitative methodology in its exploration of perspectives from high school mathematics teachers. Qualitative research is ideal for exploring and understanding a problem in an environment, as well as using the data to make interpretations (Creswell & Creswell, 2018). Qualitative investigation is best for using personal experiences and stories as data to promote change (Creswell & Creswell, 2018). A phenomenological qualitative inquiry is ideal when the scholar desires to evaluate the essence of human experiences regarding a phenomenon and holds
an interest in the interpretation of experiences (Creswell & Creswell, 2018). The general tactics of qualitative research methodologies are significant for studies that require careful analysis of acquired information and data (Cohen et al., 2013).

**Significance of the Study**

The investigation contributed to the body of knowledge on mathematical instructional strategies on improving rigor and college readiness. The results may benefit district leaders, school principals, teachers, and the school district under investigation. Investigating the role of difficulty in mathematics classrooms provided knowledge contributing to future mathematical reforms. In addition, this study provided insight the implementation of academic rigor in high school courses in hopes of assisting with minimalizing the gap present regarding student achievement and college readiness. This inquiry advanced the school district in developing college readiness among mathematic students, improving mathematic instruction, and provided insight into mathematical college preparatory programs needed to ensure future college success of post-graduate students. As well, the research informed the stakeholders of the relationship between relevant curriculum in mathematics classes and college readiness. Furthermore, this investigation is relevant to those in education, as well as administrators who value college readiness and strive to prepare students for the years post-high school graduation.

**Summary**

Chapter one conferred the introduction to the inquiry with information in connection with consequential mathematical instructional strategies to improve college readiness. Additionally, chapter one provided purpose of the study, statement of the problem, background of the problem, research questions, theoretical framework, methodology and significance of the study.
Chapter two will present a review of the literature, which explores research pertinent to mathematical instructional strategies, rigor, and college readiness in the classroom. Chapter three will report on the selected methodology. Chapter four will analyze the research findings. Lastly, chapter five will present the conclusions of the study, implications for practice, and recommendations for future studies.
Chapter 2

REVIEW OF LITERATURE

This study explored how the implementation of rigor in mathematical instructional strategies prepares high school students for college-level mathematics courses. The literature review identified and synthesized relevant articles related to the proposed study. Six sections compose this literature review. Section one provides historical perspectives pertaining to mathematics and rigor, high school college mathematic readiness, mathematic pedagogy, and mathematics education. Section two examines the importance of rigor in mathematic instructional strategies by examining various instructional strategies and learners. Section three provides a synopsis of what rigor looks like in the classroom. Section four and five explore mathematic college readiness and college remedial mathematics. Last, section six discusses the three theories that will support the research study.

Historical Perspectives

Mathematics Rigor

The concept of mathematical rigor has been prominent since the 1700s; however, through the decades the view of rigor has changed significantly (CAD, 2019). Rigor used to be difficult, hard classes and coursework, now, it is defined as the way students learn, interact, and understand the material, moving past the notion that rigor means making classes harder (Boston & Wolf, 2006). Identifying how the content is taught, assessed, and portrayed is the true indication of bringing academic rigor into the classroom to promote student success (Blackburn, 2014). With the shift of rigor to not just increased difficulty to all around student success, rigor became popular in national communications, reforms, and educational systems in the 1980s.
In 1983, the publication of *A Nation at Risk* stated that schools needed “to adopt more rigorous and measurable standards and outcomes for academic performance” (U.S. Department of Education, 1983, p. 7). Test scores of students in the United States were rapidly declining, calling for educational reform (Barnes & Slate, 2013). An educational reform sought by legislation would seek to improve student achievement and minimalize the achievement gap across the nation (Reich et al., 2013). To support this reform, in the 1990’s the department of education developed and promoted standards-based learning; the sole purpose was to push the idea that schools needed a way to measure and assess learning (Reich et al., 2013).

Unfortunately, the Elementary and Secondary Education Act (ESEA) required standards to be set but did not require any alignment between skills needed to succeed in college, thus, leaving out elements of rigor that *A Nation at Risk* demanded (LeFebvre, 2015).

As a result of the lack of focus on rigor, in 2001, the National Research Council’s (NRC) Mathematics Learning Study Committee conducted a research study on mathematics learning. The study, consisted of research from a diverse range of backgrounds such as teachers, professors, administration, principals, and business executives (Reich et al., 2013). These diverse perspectives assisted in creating an ideal view of what successful rigor in mathematics classrooms would look like. The Council created five proficiency pillars to guide mathematics classrooms in creating instructional strategies aimed at promoting successful mathematical learning (Kilpatrick et al., 2011). These pillars were as follows: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick et al., 2011). Rigorous mathematics instruction requires student engagement in meaningful mathematical activities that involve critical reasoning, communication, strategic problem solving, and fluency, which all assist the growth of conceptual understanding.
(Kilpatrick et al., 2011). All these areas assist in influencing students to be college-ready and prepared for higher-level mathematics.

To support rigor in classrooms and a more structured academic curriculum, the ACT launched several studies regarding rigor in classrooms and the effects on student achievement and college readiness. In many studies, the ACT concluded and advocated that students who take more rigorous classes in high school are more prepared to take on the level of academia presented in college (Pierson, 2015). ACT conducted studies the findings of which became widely used and referenced in high schools across the nation (Allen et al., 2017). However, while having a rigorous and challenging classroom is a necessary goal, there has yet to be any conclusion on ideal rigorous classroom instruction (Thompson et al., 2016). Blackburn (2014, 2017, 2018, 2020) discusses the importance of rigor as a key component in instruction, yet recognizes the misunderstanding by schools and teachers. Schools cannot direct teachers to implement a stronger curriculum or to teach rigor to students; administration must provide examples and guidance to assist in clarifying effective ways of teaching (Blackburn, 2014).

**High School College Mathematics Readiness**

Minimalizing the educational gap between high school and a college education is a common discussion among educational topics in legislation (Pierson, 2015). Dating back to the 1960’s, educational reforms became popular conversations; however, these conversations ended with high school graduation and did not focus on college readiness, but thirty years later, in the 1990s, educational reforms began to include not just high school education, but addressed college readiness (Conley, 2017). The college readiness work began in the 1990s and 2000s as states decided to create standards aimed to provide a guide for students choosing to enter college (Conley, 2017). Individual state colleges started their own initiatives in attempts to assure
students would be prepared and successful for enrollment post-high school graduation (Conley, 2017). Two major efforts are still discussed today: The Standards for Success, and The American Diploma Project. Each attempted to define a set of standards for multiple subject areas that would assure college preparation (Conley, 2017). The Standards for success focused on top-level universities, and the American Diploma Project focused on community colleges and employers (Conley, 2017).

In 2006, more individual colleges introduced standards to promote readiness, as well as the ACT and College Board’s creation of the College Readiness and Standards Benchmarks to set specifics (Conley, 2017). In 2010, the focus finally shifted from individual states to a nationwide context with the College and Career Readiness initiative with the adoption of the Common Core State Standards (CCSS), which is one of the most significant reforms to U.S. education in history (ACT, 2010). It was this point that college readiness became a priority, as the emphasis was not on K-12 education only, but on assuring students understood the requirements for the high school to college transition (ACT, 2010).

The CCSS required states to adopt and certify that standards set in place to prepare students to be college and career ready (ACT, 2010). These standards were content specific, as the Common Core State Standards in Mathematics (CCSSM) determined what content needed to be taught in mathematic classrooms. In mathematics, the standards focused on mathematical foundations, interventions, and processes to increase understanding and comprehension by high school graduation in efforts to prepare students for college courses. The efforts of the CCSS lead to increased efforts to assure that students could successfully transition from high school to college without remedial coursework (Grossman et al., 2011).
In 2009, when President Obama entered office, he voiced concerns regarding the effectiveness of the United States educational system in preparing students for college and careers. Each year since the 2009 Obama speech, education policymakers have called for schools to implement multiple reforms. “Right now, three-quarters of the fastest-growing occupations require more than a high school diploma. And yet, just over half of our citizens have that level of education. We have one of the highest high school dropout rates of any industrialized nation. And half of the students who begin college never finish” (Obama, 2009, para. 62). By 2011, President Obama had become one of the key voices advocating for states to increase college and career readiness standards and preparation (ACT, 2013). Although the creation of No Child Left Behind (NCLB) supported education, President Obama along with the U.S. Department of Education sought to replace NCLB with a system built around the solid goal of assisting students in high school graduation and preparing them for college (Dillon, 2010).

The replacement for NCLB was the Race to the Top (RTT) initiative, which created high standards, expectations, and performance-based assessments to align with CCSS to measure the college and career readiness of high school students (Boser, 2012). The standards specifically focused on mathematics, as mathematics courses are often one of the common barriers to college success (Burdman, 2018; Finkelsteain et al., 2012). High schools across the country experienced pressure to assure that when students graduated with a high school diploma, that adequate preparation for college had also been achieved, meaning that graduates would not be required to take remedial college courses. Research suggests that preparation in high school is a solid predictor of college success (Bettinger et al., 2013; Long et al., 2012; Howell et al., 2010). In mathematics, students who take more rigorous courses are more prepared for college coursework (Smith et al., 2017).
Around the same time as NCLB and RTT and the development of the CCSSM, the U.S. Department of Education discussed math literacy (ML) and that students needed to have increased rigor to prepare students for an increasingly challenging society (U.S. Department of Education, 2010). While mathematics is important, historically, a wide discussion is if all students need to take courses with high rigor instructional methods to be college-ready in mathematics (Cogan et al., 2019). The debate separates those students heading to vocational school and those headed to four-year colleges; furthermore, the argument lies in if both college pathways can gain support by some amount of rigor in the classroom. Currently, rigorous mathematical content outlined in the CCSSM still presents the idea that higher mathematics should be taught to students regardless post-high school pursuits in workforce, vocational school, or at a college or university (Cogan et al., 2019). Apart from the path the student chooses to take, college readiness pertains to the “level of preparation a student needs in order to enroll and succeed without remediation” (Conley, 2010, p. 21). To ensure that remediation is not necessary, students need to engage in high-rigor, challenging coursework to be adequately prepared for college (Conley, 2010).

The realization that adequate college preparation requires higher and more rigorous coursework in high schools reflecting the expectations that students will experience in college (Conley, 2010). Conley (2010) states that pushing students to take rigorous courses is intended to reduce the readiness gap seen among high school students entering college and reduce the number of students needing to take remedial mathematics courses. Studies have increasingly shown that placing students in remedial coursework increases drop-out rates and the likelihood of not completing a higher degree due to the frustration with having to take extra courses prior to reaching those that count for a college degree (Morris, 2020). Since the number of students that
take remedial mathematic coursework has historically been high, a focus has shifted to the way
teachers educate students in mathematic classrooms, calling for a drastic shift in pedagogical
strategies to incorporate higher amounts of rigor in attempts to lower the number of students
needing remedial coursework (Radford et al., 2012).

**Math Pedagogy**

Mathematics instruction in the past has focused solely on computation, where students
practice and follow the instruction of teachers until they memorize the process (Ball, 1991).
However, this process neglects to consider student thinking and mental processes, omitting an
essential component of learning (Ball, 1991). In the U.S., two types of common mathematic
instruction exist: one is teacher-led learning where the demonstration of mathematics procedures
through examples and repetition, and the other where the students lead the classroom and engage
in, demonstrations, group work, and discussions (Zhai et al., 2019). To support student critical
thinking and learning as well as encourage mathematical discussions, rigorous activities must be
implemented, as theories confirm students’ existing knowledge supports learning (Reich et al.,
2013). Furthermore, mathematics learning in the United States shifted from teacher-led to
student-led classrooms for this purpose (Willaey & Calder, 2017). Students gain more from
being engaged in activities, problem-solving, and investigations compared to procedural learning
(Calor et al., 2019).

In the history of mathematics, the debate regarding what to teach in mathematics
classrooms as well as how to teach it has been prominent (Senk & Thompson, 2020). Through
the years of mathematics education, the push for interactive teaching styles continues to
dominate topics of discussion (O’Leary et al., 2020). However, the main concern remains on
utilizing teaching methods that will assure students meet standardized test scores, known as
“teaching to the test. Administrators push teachers to meet state standards, assure students meet proficient levels on tests, and are prepared for higher education, yet education leaders do not demonstrate or explain to teachers how to accomplish any of these goals (Senk & Thompson, 2020).

Since the 1980s, mathematics education has been based solely on teacher-led lectures and student memorization (Rosenshine, 1997). Students essentially learned math through memorizing facts and plugging in numbers to equations; however, when asked to solve or manipulate equations for other purposes, students thinking skills lacked (Peter, 2012). Educators then encouraged and studied teaching students “number sense,” which was the idea that numbers are composed of other numbers and their relationships (Kruger, 2018). Unfortunately, there was extreme resistance to adopt and implement new instructional strategies, as the way of thinking was essentially changing (Rosenshine, 1997). Educational personnel during this time was not open to any mathematical change, resulting in pedagogy to remain teacher-led, with students memorizing mathematical content (Kruger, 2018).

Many years later, in 2008, the release of the CCSSM received the same kind of criticism as the ideas to implement new instructional strategies in the 1980’s (Teddlie & Tashakkori, 2012). Today, the CCSSM, which many states have implemented continues to receive harsh criticism (Rebarber, 2020). The CCSSM revived interest in mathematical pedagogical practices (Young, 2013). Since there is nothing specifically in the standards to dictate how instruction must take place, teachers have gained academic freedom in teaching practices, allowing any form of teaching the teacher desires (Teddlie & Tashakkori, 2012). The main issue is that the CCSSM require that students learn multiple ways to solve problems, as it does not solely require memorization but promotes strategic critical thinking and creative problem solving (Rebarber,
The goal of the CCSSM is not to complicate mathematics for students, but to provide many options for solving problems, in the event one method fails, there is a backup plan (Roth McDuffie et al., 2017). However, parents of today’s school-aged students attending school in the era where mathematics was solely teacher-led and memorizing are now struggling with the new methods that were not around 30-40 years ago, leaving criticism widespread.

The CCSSM increasingly emphasize the need to improve mathematical instructional strategies and appeal to a broader range of students in the classroom (Lake et al., 2017). Contradicting this movement, the pressure teachers endure to increase standardized test scores, often influences the teacher’s methods of teaching (Zosh et al., 2016). Since the United States remains the weakest country in mathematics performance, effective mathematics instructional approaches are needed (Zosh et al., 2016). In 2019, the Common Core State Standards Initiative (CCSSI) continued to acknowledge that there have not been any pedological instructional strategies set forth or defined as valuable ways to teach the standards and support students (CCSSI, 2019). However, the CCSSM continues to encourage rigor in lessons, specifically, the creation of eight mathematical practices that should be incorporated in each math lesson are as follows:

1) Make sense of mathematics
2) Reason abstractly
3) Construct viable arguments
4) Model with Mathematics
5) Use appropriate strategies
6) Attend to precision
7) Make use of structure
8) Express regularity in repeated reasoning

While the pedological and instructional components of how to get students to proficient remain vague, the emphasis on instruction that creates a student-centered learning environment, encourages critical thinking, and incorporates rigor continues to be the push in mathematics classrooms (CCSSI, 2019).

**Math Education Public vs. Private**

Mathematics education in the U.S. has continually experienced achievement gaps, and low-test scores (Groth, 2017). Teaching is the most important factor affecting student learning, thus, a discussion placing the emphasis on mathematics education across the nation happens as year after year, as students continue to struggle in mathematics courses (Fukawa-Connelly et al., 2016). Policymakers continue to promote reform efforts to improve mathematics curriculum, teaching strategies, and student understanding (Sakellariou, 2017). Research does not exist involving why certain practices or reforms are adapted in mathematics teaching and why some are not (Fukawa-Connelly et al., 2016). Little research explores the perspective of the instructors who change teaching practices to increase student mathematics comprehension (Fukawa-Connelly et al., 2016). Conducting research through comparing various types of mathematics education takes place around the United States, including, private and public education (Sakellariou, 2017).

Regardless of where students receive an education, students continue to struggle in mathematics and are not prepared to take on college coursework (Sakellariou, 2017). Widely documented is the difficulties with the mathematics education provided in the U.S. (Groth et al., 2017). Most commonly, each year improvements to teacher education through research take place, new instructional designs, interventions, and various teaching strategies (Groth et al.,
Unfortunately, none of these improvements make lasting effects on student preparedness for college (Eukawa-Connely et al., 2016). The only minor difference is between how rigorous mathematics education in private schools is versus those in public (Sakellariou, 2017)

Academic outcomes are of growing interest in students who attend private high schools versus those who attend public schools (Frenette & Chan, 2015). Dissatisfaction with the public-school system in the United States has led to an increase in school choice policies and more parents seeking private schooling options with the desire to remove students from public schools to have an academic advantage (Foreman, 2017). Mathematics is an important component in student education, as it helps develop problem solving, reasoning, and critical thinking skills (Iqbal et al., 2018). In most circumstances, students who attend private schools outperform those who attend public schools (Sakellariou, 2017). Private high school mathematic scores are significantly higher than those of public schools (Frenette & Chan, 2015). Private schooling provides students with a high-quality learning in an efficient way due to more accountability of students (Baum & Riley, 2019). School resources, rigor, and practices are part of the difference in academic outcomes, leading to an interest in studying what educational practices take place in private schools (Frenette & Chan, 2015).

With mathematics being one of the most important subjects in schools worldwide, the literature is full of information regarding how to teach and influence the education of today’s youth (Imam, 2016). Iqbal et al. (2018) concluded that mathematics teachers in private school environments have better assessment and classroom practices. In addition, most private secondary school boards require more challenging assessments and grading scales as most hold the label as college-preparatory environments, which adequately prepare students for college education (Barnett, 2016). The number of formative and summative assessments are generally
significantly higher in private schools, as assessment promotes learning (Xiao, 2017). Schools with increased testing practices use teaching strategies and the test itself to promote learning, reflection, and self-regulation (Xiao, 2017).

Across the nation, students who attend private school outperform students who participate in public education (Sakellariou, 2017). Policymakers continue to implement mathematical reforms hoping that students will perform academically better when attending high-achieving schools (Allensworth et al., 2021). However, there remains a gap in knowledge regarding private education benefits, as private schools significantly differ across the nation (Allensworth et al., 2021). The focus remains on the amount of rigor and the presentations of mathematics in various classrooms across the country to determine if an educational benefit is present. Thus, there is a greater need to study current mathematics teaching strategies and explore the rigor employed throughout classrooms (Wilson et al., 2019).

**Mathematics Instructional Strategies**

New developments in the CCSSM have emphasized rigor implementation in mathematic instructional strategies (Wu & An, 2016). The shift to a rigor-filled environment encourages a diverse instructional environment full of strategies to encourage conceptual understanding, procedural skill and mathematical fluency, problem solving skills, and application (Wu & An, 2016). Administrators continue to challenge classroom teachers to develop mathematics instruction to meet the needs of the rigor requirements seen in the CCSSM (Wu & An, 2016). Professional development seminars attempt to highlight enhancing teaching practices, however, the lack of support to assist mathematics teachers in diverse instructional strategies remains (Wu & An, 2016).
Active rigorous learning strategies are important in classrooms (Bakar & Ismail, 2020). Since mathematics is one of the complex subjects that students generally do not like, the instructional strategies become increasingly important (Legg & Locker, 2009). Diverse learning methods as well as implemented rigorous strategies create positive perceptions and confidence in learning (Smith & Mancy, 2018). Teachers continue to implement active learning strategies to assist students in navigating through rigor (Bakar & Ismail, 2020).

**Rigor in High School Instruction**

A mutual consensus states that for students to be college and career ready that courses taken in high school need to be full of rigor and challenging content (O’Daniel, 2019). However, three problems exist regarding rigor, the definition of rigor, which changes depending on the course, what rigor will look like in the classroom, and the measurement of rigor in classroom instruction. Strong et al. (2001) states that rigor is the goal of helping all students develop complex, ambiguous, and challenging material. An important aspect regarding classroom instruction is that rigor does not mean simply making problems or homework assignments harder, it is raising the expectations and capabilities of what the students are doing through activities and scaffolding (O’Daniel, 2019).

In 2007, a published study conducted by the ACT highlighted the effects of rigor in classrooms (ACT, 2007). This publication created an increased interest in educational strategies, leading to several schools pushing for curriculum reforms to increase rigor throughout instruction (O’Sullivan & Dallas, 2017). The purpose of increasing rigor is to eliminate or lower the skills gap the is present between high school and college education (O’Sullivan & Dallas, 2017). Simply requiring students to take more core courses such as math, science, and language arts is not the key to success as often thought. To reach success, the learning skills that students
gain from researching, communicating, thinking critically, and problem solving is truly what increases the learning environment and opportunities for students (O’Sullivan & Dallas, 2017). Colleges are now pushing for rigorous high school instruction and in-depth learning opportunities to expose students to the rigor present in college environments (Wahleithner, 2020).

Some in the education community do not know the importance of rigor, thus consideration needs to be placed in two places; classrooms that have rigor and those that do not (Morgan et al., 2018). Learning from classrooms that understand the needs to prepare students for college success is important for educating those who do not (Song & Zeiser, 2019). Classrooms with increased academic intensity prepares students with the skills needed after graduation (Morgan et al., 2018).

In a study, mathematics teachers stated that implementing an intense and challenging curriculum was demanding, as training and professional development regarding rigor lacks in this area (Bay-Williams, 2016). However, the same study also reported that mathematics teachers are doing a better job at implementing mathematical concepts and are especially paying attention to the thought process, using mathematical terminology, and making real-life connections (Bay-Williams, 2016). Utilizing multiple strategies and thinking procedures assists in developing conceptual understanding and strengthens procedural fluency (Wojcik, 2017). In support, one definition of rigor in the classrooms is increasing and finding a balance between conceptual understanding, procedural fluency, and application, exactly what teachers are doing, yet the teachers are just beginning the procedures to reach this milestone, practices still need to be perfected (Bay-Williams, 2016).
**High School Instructional Strategies**

Instructors use two common instructional strategies in mathematics classrooms around the nation: the traditional teaching style, and student-centered learning which includes a diverse range of strategies to meet the learners needs (Brahier, 2013). The traditional teaching style emphasizes memorization and the student-centered learning focuses on engaging students in the rigor of reasoning and critical thinking problems (Lorenzen, 2017). Classrooms still dictated by the teacher transferring knowledge to the student essentially holds students back and prohibits them from thinking critically, as all learning is dependent on the knowledge of the teacher, there is no room for investigation or inquiry (Ayala et al., 2017). Traditional pedagogy is one of the main reasons that student engagement, motivation and interaction is so low in mathematics classrooms (Aji & Khan, 2019). In student-centered learning, the teacher is the facilitator and assists in guiding student knowledge to mastery (Matthews, 2020). The most successful classrooms have purposeful sequencing through rigorous activities to lead students to a higher level of understanding (Thompson et al., 2016).

To develop the skills leading to higher-level thinking and understanding, students need the opportunity to be engaged in complex learning environments (Edmunds et al., 2017). The instructional strategies of teachers have become the key to preparing students for success once entering post-secondary options (Vargas et al., 2019). While teaching strategies must be meaningful and filled with rigor, the idea of what rigor looks like in classroom instructional strategies remains vague (Blackburn & Witzel, 2018). The commonality regarding teaching is that teachers will design classrooms to “incorporate a level of cognitive challenge or academic rigor that will allow students to build their expertise in 21st century skills” (Edmunds et al., 2017,
Mathematical teaching and classroom strategies that engage students, as well as understand the diversity of learners in the room assist in academic growth (Vargas et al., 2019).

Providing effective mathematics instruction in the classroom is challenging for most teachers (Althauser, 2018). Most teachers think that the current CCSS-M include more rigor than the past, thus challenging teachers need to be more creative with teaching practices to meet all expectations (Bay-Williams, 2016). Teachers have more responsibilities as instructors now than in the past (Althauser, 2018). Since the highest rate of failure is in mathematics classes high school instructional strategies need to be supportive and on the same level as the CCSS-M (Vazquez et al., 2018). The main goal remains, to prepare students to perform at high academic levels and establish higher order thinking skills to be successful in future educational endeavors (Althauser, 2018).

**Interactive Teaching Strategies**

In many classrooms, teachers discourage students from talking and communicating with fellow classmates (Aji & Khan, 2019). Across the nation, many secondary classrooms include passively engaged students, bringing the level of mathematics education down to mediocre (Aji & Khan, 2019). However, research shows that students learn and retain 90 percent of what they say, discuss, or complete during an activity in class (Tate, 2015). Interactive teaching methods involve interactions between both the teacher and student equally while also involving interactions among other students in the classroom (Giorgdze & Dgebuadze, 2017). Various engaging activities greatly benefit students, as the memorization and easily recall of information in the future is easier when the body is engaged (Tate, 2015). For years, teachers have tried to create interactions in classrooms to increase learning opportunities (Tan et al., 2019).
Interactive mathematics lessons keep the students continually thinking and processing information. In-class interactive teaching is associated with improved learning outcomes for all students, and generally decreases achievement gaps (Ayala et al., 2017). Specifically, active learning benefits academic outcomes in mathematics students resulting in higher academic grades (Ayala et al., 2017). In private schools, classroom sizes are generally smaller which allow for more student-student discussions and activities able to take place (Morris & Perry, 2019). A component impeding active learning strategies in the classrooms of public schools is time constraints, private schools often get the luxury of block scheduling or longer class periods with more flexibility to incorporate activities (Morris & Perry, 2019).

Utilizing a variety of interactive teaching strategies in mathematics classrooms is extremely beneficial (De Vita et al., 2018). Technology, activities, discussions, and interactions all support a diverse and interactive learning environment by appealing to students through providing diverse alternative learning options (Sanger, 2020). Some scholars argue that teaching strategies in mathematics classrooms must remain teacher-led, as it is extremely hard to have students discover mathematics, however, effective instruction is dynamic (Lo & Hew, 2017). Teachers use effective interactive teaching strategies to influence students thinking, reasoning, and reflection (De Vita et al., 2018). Teachers need to continually ask themselves if students are engaged and interacting with the material and content, if that answer is no, instructional strategies need alteration (De Vita et al., 2018).

Interactive teaching strategies aim to promote critical, reflective, and deep thinking through encouraging evaluation skills while enhancing the educational experience (Senthamara, 2018). Using various strategies in the classroom assist in identifying gaps in existing knowledge, forces students to analyze, organize, review, compare concepts, and reflect on content
(Senthamara, 2018). To meet the needs of students, classroom teachers must adapt new teaching and learning strategies, address the students’ learning styles and needs, and assure the needs are met of all students' through various activities (Senthamara, 2018). Common classroom activities promoting engagement include, discovery activities, brain-storming, group tasks, and hands-on problem solving (Giorgdze & Dgebuadze, 2017). One of the two most common techniques used is when the teacher and learner swap the traditional roles, allowing the student to actively engage in the learning process and be the center of the classroom, and project-based learning (PBL) (Giorgdze & Dgebuadze, 2017). These teaching methods all shift students from passive listeners to active classroom participants (Giorgdze & Dgebuadze, 2017).

**Project-Based Learning**

In education, diverse forms of teaching have direct impacts on learning (Anwer, 2019). Educational experiences aim to provide students with various competencies and skills required for future employment opportunities (Anwer, 2019). Project-based learning (PBL) has become a popular style of teaching, as students learn through an interactive discovery process (Shih & Tsai, 2017). By origin, PBL is the “learning by doing” method (Trubitsyna & Muimaster, 2016). Through aiming to promote student teamwork, critical thinking, interpersonal communication, and project management abilities, PBL supports not only classroom educational growth, but growth to succeed in society (Shih & Tsai, 2017; Helle et al., 2006). Learning through a constructivist approach allows a creative environment keeping the participant active through reflection, eventually leading to problem-based, transformative learning (Horntvedt, 2018; Levin, 2010). Trubitsyna and Munimaster (2016) posit modern education requires new forms of teaching, including PBL, that do all the following:
1. Provide a high level of knowledge and competence with the ability to find information and use it.

2. Develops each student as a creative personality capable of practical work.

3. Engages students in active learning activity.

4. Forms learning and investigatory skills and critical thinking.

5. Facilitates the establishment of good relationships between the students.

6. Teach how to search for information and use it.

Increasing rigor and engaging students in the classrooms is an essential component of education (Craft & Capraro, 2017). PBL is an increasingly favored way for teachers change the traditional teaching styles in attempts to academically provide a rigorous learning experience where students apply knowledge and critical thinking skills outside of the classroom (Baines et al., 2015). While PBL is a valuable educational strategy, some teachers struggle to incorporate rigor into lesson plans and activities (Edmunds et al., 2017).

PBL potentially creates relevant and rigorous learning in mathematics classrooms while being appealing to the variety types of learners seen in the classrooms (Harada et al., 2015). Encouraging students to access, retrieve, and produce information is a way to increase rigor and learning opportunities Harada et al., 2015). Having PBL in the STEM classrooms forces engagement and interactions in environments that are widely managed and dictated by the instructor (Craft & Capraro, 2017). Projects encourage and support students to learn at high levels through scaffolding and different levels of comprehension and thinking (Craft & Capraro, 2017). STEM PBL blends rigor and relevance to increase student engagement in the classroom and promote high levels of learning (Bicer & Lee, 2019). In mathematics specifically, students
watch a video pertaining to the lesson and objectives, the next day students would work together to create a hands-on project to fully understand and expand on the concept.

The shift from teacher-led instruction to student-led instruction has lasting effects if designed correctly, the framework of PBL assists students in preparing them to take on the challenges and rigor of future college classes (Boss & Larmer, 2018). PBL creates collaborative problem solvers who are ready to take on the challenges in society (Wan Husin et al., 2016). The research supports implementing strategies such as this, as having students “do” and apply” influences the rigor and relevance to any class setting while additionally improving engagement and critical thinking, which are essential educational components (Jollands & Molyneaux, 2012; Hanney & Savin-Baden, 2013).

**Types of Learners**

In classrooms, students learn and process information in various ways (Quinn et al., 2018). Learning styles are defined as factors, behaviors, and attitudes that facilitate learning for a student in classrooms (Cassidy, 2014). Understanding the learning styles of students is useful, as it allows instructors to use appropriate teaching styles and techniques (Quinn et al., 2018). With each student having specific learning preferences, teachers attempt to use a variety of activities and tasks to encompass all student needs (Quinn et al., 2018). Knowing the learning styles of students also assists in identifying studying challenges, weaknesses, and strengths (Quinn et al., 2018). The goal is to give students the knowledge and skills to be successful, even if this is not the same for each student (Quinn et al., 2018).

Ideally, the optimal learning environment takes place through using the primary learning style of the student, as retention of information increases in this scenario (Martinez & Tuesca, 2019). Felder and Silverman (1988) assert there are several types of learners that recognized and
discussed in the educational system; active and reflective learners, sensing and intuitive learners, visual and verbal learners, and sequential and global learners. Active learners learn by doing, through actively engaging with the content and other classmates while reflective learners prefer to work alone by thinking through things themselves prior to attempting the content or task (Fedler & Silverman, 1988). In addition, sensing learners are concrete thinkers who learn and understand the facts prior to the mechanics and completion and intuitive learners think abstractly while preferring to learn concepts and significance (Fedler & Silverman, 1988). Visual learners prefer pictures, figures, and diagrams and verbal learners would rather read information or be told explanations (Fedler & Silverman, 1988). Additionally, sequential learners think linearly through the thought process by obtaining information in small steps, and global learners integrate the thinking process by putting information together in larger steps (Fedler & Silverman, 1988).

With multiple learning styles present, this presents itself as a difficult task for teachers to take into consideration how to reach each learner in a single lesson (Coffield et al., 2015).

The growing diversity in classrooms demands a wide range of instructional strategies (Suprayogi et al., 2017). A well-rounded curriculum benefits every type of learner in the classroom (Suprayogi et al., 2017). The expectation that teachers will use teaching strategies that effectively accommodate the diverse needs of students in classrooms continues to draw attention (Yeo, et al., 2019). Creating an environment that has rigorous academic differentiation to support low and high students in the same classroom has put increased pressure on teachers (Heacox, 2018).

All students have different learning styles as classrooms experience a diverse range of students with various needs (Amir & Sari, 2018). Commonly today, teachers manage a large class full of academically diverse students (Yeo, et al., 2019). Years ago, individualized
instruction became ideal, where teachers created customized lesson plans for each student in the classroom (Tomlinson, 2017). Even though this appeared to be a great idea, this was quite exhausting for teachers (Tomlinson, 2017). Today, the encouragement of using differentiated instruction to reach all students without having to create individual lesson plans is common (Tomlinson, 2017). Reaching each type of learner can happen through a variety of classroom activities and assignments that appeal to all students in the room (Tomlinson, 2017).

The learning styles of students contribute significantly to achievement and learning efficiency (Wei et al., 2018). Students learn in a variety of different ways, thus the need for a diverse range of teaching strategies (Wei et al., 2018). The wide range of learning styles also appeals to the gifted and talented students as well as the lower learners (Wei et al., 2018). The need to continue teaching a wide range of varied abilities and needs in a single classroom continues to grow (Goode-Middleton, 2017). Each year, classrooms contain students who vary greatly in mathematical knowledge, yet, leaving the teacher to identify strategies and methods to address the diversity in the classroom (Goode-Middleton, 2017). Furthermore, this includes deciding which teaching methods are best to use, how to assign homework, and how much students need to work on practicing skills (Goode-Middleton, 2017).

Math Homework

Educators explore and study various types of mathematical to determine-effects on student achievement (Minke, 2017). Three common purposes of mathematic homework are practice, preparation, and extension (Rosario et al., 2015). Each purpose dictates which type of homework assignment assigned promotes student engagement and meaningful learning opportunities (Minke, 2017). Homework should not be solely about learning the current content,
but needs to broaden student understanding and build on essential skills needed in society and future careers (Vatterott, 2010).

Practice homework focuses on tasks taught recently to assist in increasing speed, mastery, help study for tests, and retain skills over time (Rosario et al., 2015). This type of homework promotes proficiency and fluency through mathematical facts learned. Preparation homework prepares students for the upcoming lessons and what is to come later in the lesson or year (Rosario et al., 2015). The homework encourages students to think about previous homework topics and prepare for future topics by reviewing content in the future lessons in the textbook to start gaining an idea of what the content will look like (Minke, 2017). Last, extension homework promotes the shift of previous learning to new tasks (Rosario et al., 2015). This extends the thinking and requires high, abstract level thinking to be successful (Minke, 2017). Most often, this assignment encourages students to work with peers, think critically, and combine multiple past topics and ideas to complete the assignment (Rosario et al., 2015). Ideally, this type of homework provides a rich, learning experience for students through discovery (Vatterott, 2010).

Mathematics homework is the most popular and the most controversial, teachers are under scrutiny when assigning material due the next day (Xu et al., 2017). The design of a mathematics classroom has significant impacts on students (Vatterott, 2018). The organization of the content, scaffolded learning, checks for understanding, and homework all contribute to the quality of learning the students receives (Vatterott, 2018). A common conversation is the effectiveness of take-home homework Vatterott, 2018). Students often need time to process and understand content. Homework allows for students to continually work on newly developed skills (Bennett, 2017). However, for students who already understand the material, homework is simply busy work, and a waste of time as once reaching mastery, students should be increasing
and adding to current knowledge, not repeating tasks of the same caliber (Bennett, 2017). Assuring the distribution of quality and meaningful assignments is an important aspect of the learning experience (Vatterott, 2018).

Increasing the effectiveness of homework assignments is essential for educators, as not all homework is beneficial to students (Carr, 2013). However, when instructors design homework and implement assignments properly, it is a valuable tool and asset to the student’s education (Carr, 2013). A common issue with assignments is that students tend to copy answers found online or from a friend to get the assignment completed (Sarmiento et al., 2019). Several answers support why students cheat and copy assignments. One is that the student does not know the material, and a second is that the student is bored with the assignment and views it as busy work (Sarmiento et al., 2019). Thus, the need to create meaningful and effective homework assignments for students is essential (Sarmiento et al., 2019). Math homework does not always have to be a problem set; however, this remains the most common homework assignment in mathematics classroom (Xu et al., 2017).

Various studies support the need for homework and the correlation of homework and academic success (Xu et al., 2017). A positive association between homework and achievement is present in high school environments (Fernandez-Alonso, 2015). This achievement develops from the student perceptions of homework, students report that homework is valued if it is challenging and assigned in a way to support learning (Dettmers et al., 2010) Students also reported that homework is not generally completed if the skills are already mastered, as the student then sees the homework as pointless (Dettmers et al., 2010).

Each homework assignment should have five characteristics: purpose, efficiency, ownership, competence, and aesthetic appeal (Vatterott, 2017). To be appealing to students,
each assignment must have a clear academic purpose, such as practice, check for understanding, or expand the learning, it must be enjoyable and interesting for students to get the most out of the learning experience (Vatterott, 2010). Schimmer (2016) discusses that teachers should consider the following questions to make sure homework is a productive, meaningful learning experience:

1. Is it learning-centered?
2. Is it necessary?
3. Is it reasonable?
4. Is it high quality?
5. Are students ready?
6. Were students involved?

In relating Schimmer’s six questions with Vatterott’s five characteristics of homework, it supports that, “Homework should be meaningful, purposeful, efficient, personalized, doable, and inviting” (Vatterott, 2010, p. 15). The influence of homework is complex, as various styles of homework will appeal to various learners, however, homework still needs individualization to meet the needs of all learners (Schimmer, 2016; Vatterott, 2017).

**Academic Rigor**

The creation of the current Common Core State Standards and individual state standards required more rigor (Blackburn, 2008). According to research by Blackburn (2008, 2013, 2014, 2017, 2020) students need rigor to not only perform well in high school, but to be prepared for college and the workforce. Analyzing how rigor is used in classrooms and how teachers utilize high expectations to create environments full of rigor is the key to determining and creating success (Blackburn, 2008). When correctly done, through implementation of rigor, the teacher is
doing his or her best to prepare students for academic success in post-graduate years (McNulty & Quaglia, 2007).

With academic rigor being an important aspect of a student’s educational experience, challenging and engaging students in a way to prepare them for college and careers is essential (Boser & Rosenthal, 2019). Assisting students to achieving high order thinking skills and demonstrating knowledge through a variety of strategies actively prepares them for future college experiences (Matsumura et al., 2008). Policymakers and researchers often discuss how course selection is a small component of success, as rigorous content, instruction, and assessment must also be present in the classroom (Matusevich et al., 2009; Boser & Rosenthal, 2019).

Studies and statistics show that the United States K-12 education system lacks rigor, especially in science, technology, engineering, and mathematics (STEM) courses (Sahin & Top, 2015). Schools are under pressure to increase rigor and provide a more robust education (Harada et al., 2008). Incorporating a challenging education in the classrooms creates high expectations and encourages students to learn and perform at high levels (Blackburn, 2008). Using this method, teachers support students through the educational year to achieve, reach, and demonstrate high levels of learning (Blackburn, 2008).

Across the nation, policy makers have continued to express concerns with the lack of rigor and intensity in public high school courses (Harada et al., 2008). Contradicting, the nation’s Catholic high schools hold students to higher standards with rigor filled environments, advanced courses, and college readiness preparation, in fact, most private high schools are college preparatory environments (Fuller & Johnson, 2014). Environments such as these build relationships between students and teachers to allowing for deeper discussions and a willingness to ask questions and be academically successful (Sarra et al., 2020). Elevating expectations and
increasing the level of challenging content changes the way students think and process information, thus contributing to academic growth (Cobb, 2018). Difficult curriculum and high standards set students up to be challenging but also holds the expectation that each student will be successful (Cobb, 2018). The goal of any educational environment is to assure that students will receive a proper education and graduate with knowledge to be successful in life after high school (McMahon et al., 2017).

To implement rigor in classrooms students must be familiar with the high expectations and requirements of the class (Rose, 2020). Setting appropriate learning expectations in the classroom from the beginning of the year allows students to understand the tone of the classroom (Rose, 2020). A teacher who holds students to high expectations expects all students, even with differing levels of academic knowledge to perform at high levels (Rose, 2020). Teaching with high expectations is about getting lower level, underperforming students to believe in themselves and build a belief that success is obtainable (Saphier, 2016). This is accomplished by scaffolding and implementing rigor across class curriculum to get students to reach a high level of understanding (Saphier, 2016).

Equally important, creating a classroom with the ability to address all student needs and move him or her to a higher level of learning is the goal of each classroom (Blackburn, 2018). Five rigor components are critical in developing course rigor: critical thinking, challenge, mastering complex material, time and labor intensity, and production of credible work (Johnson et al., 2019). Using these classroom techniques throughout the curriculum assist the teacher in developing effective teaching practices which appeal to a variety of students and various types of learners (Johnson et al., 2019).
While rigor involves high expectations of the student, there are a few myths regarding the definition and uses of rigor (Blackburn, 2020). Rigor does not necessarily require increased homework assignments or more work for students, it is entirely implemented in the ways teachers present information and set up classrooms (Blackburn, 2020). Teachers much develop a well-rounded curriculum to set up students for success (James, 2016). Keeping students challenged and invested in learning paves the way to a successful educational experience through a variety of classroom components (James, 2016).

Moreover, a complete curriculum contains high-level instructional strategies used to challenge and promote a deeper level of thinking (Blackburn, 2020). Classrooms filled with activities that promote critical thinking as well as extended learning opportunities support the task to challenge students daily (Blackburn, 2020). In rigor filled classrooms, teachers push students to respond at high levels and do not accept low-level responses (Blackburn, 2020). Each opportunity in the classroom is an opportunity to grow and understand, probing the student to continue thinking and not give up is part of the teaching process (Blackburn, 2020).

**Engagement and Activities**

Various levels of connection, interaction, and learning demonstrated in a classroom influence the extent to which students are engaged (Gourgey et al., 2010). Increasing rigor to keep students engaged and actively learning in the classroom has slowly become an essential part of education (Craft & Capraro, 2017). Through increasing rigor, the academic achievement of students, as well as classroom engagement improves creating ample classroom opportunities to benefit from classroom instruction (Paige et al., 2013). An essential part of education, is assuring that teachers find ways to increase both rigor and engagement simultaneously (Craft & Capraro, 2017).
Activities that hold student’s attention and present ample challenges are ideal for the classroom, however, they are not easy to come by (Blackburn, 2018). In all classrooms there are different levels of learners. Implementation of rigor must vary to each student in different ways and levels through various activities to be successful (Blackburn, 2018). Tomlinson and Imbeau (2011) state that differentiating rigor means placing an emphasis on each individual student, meeting their needs. Assuring that each student has what they need to be successful is extremely important (Tomlinson & Imbeau, 2011). Instructors may need to alter activities to challenge the highest achieving students or change them support the lower students (Tomlinson & Imbeau, 2011).

In mathematics specifically, engaging students to learn is a critical component of education as students learn more effectively when engaged (NCTM, 2018). Current standards and curriculum for the past ten years have encouraged instructional practices based around increasing engagement and student achievement (Bobis et al., 2016). Unfortunately, engagement decreases in high schools, as interactive and engaging activities no longer take place and students encounter teacher-led instruction (Bobis et al., 2016). At this moment, when students are no longer engaged or interested in classroom activities, the decision to opt out of the STEM fields or pursue a future college degree in a STEM field declines (Greene, 2015; Sinatra et al., 2015). The change in mindset regarding STEM fields, especially mathematics hinders students from building further confidence in being successful in college courses (Sinatra, 2015). The same requirements apply to college, as students enter college courses, largely led by professors or instructors, the lack in activities and engagement cause students to discontinue the mathematic academia (Greene, 2015).
High School Dropout Due to Academic Rigor

A major educational challenge is ensuring that all students graduate from high school for post-secondary pursuits like college and careers (Rumberger, 2020). The number of students who drop out of high school is alarmingly high year after year (U.S. Census Bureau, 2012). In 2018, according to the U.S. Census data, over half a million students in the U.S., in grades 10-12 drop out of high school (Snyder, de Brey, & Dillow, 2018). Schools have an influence on student achievement, and trying to lower the dropout rates, as poor academic performance has been a long predictor of dropout rates (Rumberger, 2020).

Nationally, dropout rates are a serious problem recognized by administrators and school districts (Freeman & Simonsen, 2015). Meaning, high schools are increasingly under pressure to increase graduation rates and lower dropout rates (Harada et al., 2015). Assuring that high school students receive the proper support and assistance needed to be successful in courses is essential. Students who drop out are at increased risk of never returning to finish a high school diploma which results in the inability to never complete any form of college education (Rumberger, 2020).

Lack of academic achievement is a significant factor contributing to high school dropout rates, if a student struggles academically, there is a greater chance that the student will drop out and discontinue school (Choi & Kim, 2018). School academic engagement is one of the main factors in determining the likelihood of student dropouts (Bilge et al., 2014). Students who are engaged in learning in academic environments generally enjoy classes, thus are less likely to dropout (Arlinkasari et al., 2017). Therefore, environments with high rigor, various academic teaching strategies, and classroom activities have a better opportunity of keeping students in high school and preparing students for college and university enrollment (Blackburn 2020).
With the three highest indicators of high school dropout being poor high school attendance, low course completion, and low grade-point-average, schools are attempting to address these factors early on in educational careers, such as in middle schools (McKee & Caldarella, 2016). The emphasis is being places on the first semester of ninth grade, as this semester is one of the most critical factors in a student’s education (McKee & Caldarella, 2016). Thus, schools are ensuring that students have the support, assistance, and guidance needed to be successful and help them through troublesome classes such as STEM courses (Alipio, 2020).

**Perception on Rigor**

Policymakers and educators are continually concerned regarding student preparation and ensuring the mastery of proper skills and knowledge prior to leaving high school (Edmunds et al., 2017). Teachers commonly state that increasing rigor, to encourage students to be creative and innovative, think critically, communicate and collaborate effectively, and problem-solve is essential in education experiences (Edmunds et al., 2017). When asked, teachers advocate for various challenging content to give students the opportunity to engage in integrated and complex learning activities (Asghar et al., 2012). Through administrative recommendations, encouraging teachers to implement strategies to incorporate challenge, rigor, and increase the 21st century skills students need for post-graduation (Edmunds et al., 2017).

Across the disciplines, various teachers in the past have reported that academic rigor assists in implementing critical thinking skills and encouraging self-motivated learning (Culver et al., 2019). Commonly, several studies discuss the academic rigor of online courses, however, few discuss rigor in mathematical classrooms where face-to-face instruction is taking place (Culver, 2019). When asked, teachers often state that they participate in professional development activities regarding rigor, however, presentations do not offer ways to implement
rigor through mathematical instructional strategies, leaving teachers with the understanding that rigor is important and academically assists students, but with no knowledge about how to make instruction more rigorous (Viney, 2016).

Several studies address student perceptions of rigor (Chaudhuri, 2018; Edmunds et al., 2017; Wyse & Soneral, 2018). The first common theme states that students who develop relationships with teachers or professors to take on the challenges of rigor as support is readily available and students feel comfortable seeking it out (Jawad, 2017). Students also reported that learning to build relationships in high school courses assisted in building relationships in college as the process was known (Chaudhuri, 2018). Thus, relationships assist in making rigorous environments a positive experience, allowing stronger curriculum to adequately prepare students for college (Chaudhuri, 2018).

A second theme across studies is that students view rigor as relevant in high school and understand that college and career plans will require rigor to be an accomplishable task (Chaudhuri, 2018). Making students aware of how rigor will influence and relate to future careers and goals provides an insight to the future. Academic and career relevance has a positive impact on helping students understand and overcome the challenges of future rigor (Jawad, 2017).

**Math College Readiness**

A study conducted by the National Center for Education Statistics (NCES) reports that college enrollment will reach record levels each year between 2020 and 2025, with a 15% increase in college enrollments (U.S. Department of Education, 2019). The role of high schools is to prepare students for post-secondary options and to be successful with any challenges that after high school graduation (Snir et al., 2017). Concerns and discussions continue regarding
how effectively the nations K-12 schools are preparing graduates for college (O’Daniel, 2019). The majority of middle and high school students report plans to attend post-secondary options, whether it be two-year or four-year colleges and universities (Kurlaender et al., 2019). However, many students entering college are not prepared for the rigor of college level mathematics (Bailey et al., 2015).

The struggle with college preparedness for mathematics courses has called for many reforms, yet, all have been largely unsuccessful (Varner, 2018). Furthermore, by needing a reform, many stakeholders such as policy makers, professors, politicians, and institutional faculty continue to debate how to better the transition from high school to college mathematics, a solid conclusion has not been determined to get students college ready (Bailey et al., 2015). Thus, improving mathematics college readiness and preparation remains a key component in the minds of state and local educational stakeholders who are actively attempting to increase post-secondary enrollment and success (Asim et al., 2019).

**Conley’s Four Factors of College Readiness**

Conley (2007) states that college readiness is not dependent on high school GPA or national tests, as they are inaccurate measurements of post-secondary preparation. Conley et al., (2017) state that college entrance exams do not measure the proper skills and requirements needed for college success, and that other factors influence college readiness. In 2017, after years of studying college readiness Conley came out with a definition of college readiness along with four factors taken into consideration aside from high school GPA and standardized test results (Conley, 2017). The four factors are tools and skills needed to produce students adequately prepared to take on the post-secondary rigor and coursework (Jawad, 2017).
The first factor which influences college readiness is the establishment of key cognitive strategies (Conley, 2007). Furthermore, Conley (2007) describes the cognitive strategies as skills that “have been consistently and emphatically identified by those who teach entry-level college courses as being as important or more important than any specific content knowledge taught in high school” (p. 5). The sole purpose of the cognitive strategies is to describe the patterns of needed intellectual behaviors to develop over time that have an influence on assuring that students are college ready by the time high school graduation takes place (Jawad, 2017). These strategies include rigorous thought processes such as critical thinking, in-depth analysis, interpretation of content, problem solving skills, and reasoning development (Jawad, 2017).

Influenced by the first, the second factor is key content knowledge and skills. Conley (2010) states that “understanding and mastering key content knowledge is achieved by processing information so that its structure becomes more apparent then probing, consolidating and applying that information by means of the key cognitive strategies” (p.35). Further analyzed, these content knowledge skills are split into overall academic skills and main academic subjects and knowledge skills (Conley, 2017). Overarching academic skills are necessary in writing and research courses as students are assessed frequently based on writing style and thought process in research (Conley, 2010). In post-secondary courses, students do more writing than experienced before, thus making these skills important (Pfrenger et al., 2017).

Main academic subject and knowledge skills are key components needed for courses such as mathematics (Conley, 2010). Mathematics content builds off previous knowledge and courses making content retention an important factor as a basic understanding is necessary to continue up the scale of college courses (Ngo, 2020). “College ready students possess more than a formulaic
understanding of mathematics. They apply conceptual understandings to extract a problem from a context, use mathematics to solve a problem and then interpret the solution back into the context. They know how and when to estimate to determine the reasonableness of answers” (Conley, 2010, p. 37).

Academic behaviors comprise the third factor, as self-awareness, self-monitoring, and study skills are important factors of success (Conley, 2017). Behaviors such as these do not depend on any student knowledge in content areas but includes being able to self-assess and alter the response and study skills when content is challenging (Conley, 2017). Understanding when to continue studying and change study habits are key indicators of academic behaviors that prepare students for college (Jawad, 2017). These skills help students not only study but prepare to take exams, seek out resources for assistance, study in groups, wise time-management, and academic preparation, essentially preparing students for the rigor of college (Jawad, 2017).

The last factor is contextual skills and awareness which is the knowledge of understanding what a college environment is like socially and the amount of rigor and challenges expected (Conley, 2017). Conley (2007) states that “success in college is enhanced for students who possess interpersonal and social skills that enable them to interact with a cross-section of academicians and peers” (p. 17). Additionally, students need to be aware of college specifics including admissions, grade requirements, tuition, testing, and other processes to learn to value to experience (Conley, 2007).

Many factors influence college readiness; high school experiences, rigor, social factors and knowledge all play a role in preparation (Blackburn, 2018). Using rigor, relevance and relationships in addition to GPA and test scores assist in analyzing college success (Camara, 2013). Drawing attention to personality and non-cognitive qualities are key considerations when
considering in assessing if students are college ready, rather than focusing purely on academic qualifications (Conley, 2017; Camara, 2013).

**Predicting College Success**

Across the nation, policymakers and school districts have become increasingly fascinated with the goal of preparing all students to graduate from high school ready to succeed in college (Allensworth et al., 2018; Edmunds et al., 2017). Educators have also been using early warning and college readiness indicators to assess if students are ready for college and if there are any factors that may impede college success (Allensworth, 2018). Often, colleges use GPA and standardized test scores to determine college admittance, however, there are flaws present in each of these methods (Akos & Ktetchmar, 201).

Standardized tests are ethnically and culturally biased and have a high correlation with socio-economic class (Wilson & Santelices, 2017). This bias and issue cause standardized tests to receive harsh criticism stating that standardized tests measure other factors besides academic potential (Akos & Ktetchmar, 2017). GPA scores also receive criticism as all high schools are different, and GPA does not accurately reflect the intensity of the courses or curriculum (Warren & Goins, 2019). Several studies seek to understand factors that influence college readiness and success without focusing on grades and test scores (Beattie et al., 2018). Allowing administrators, educators, and faculty to understand components which predict and influence college success would allow assistance and emphasis in these areas to support and guide students (Beattie et al., 2018).

Setting GPA and standardized test scores aside, literature strongly suggests that secondary school courses and performance is the highest indicator of how successful students will be in college years (Anderton et al., 2017). Specifically, in mathematics, success is not
determined by the high school GPA but by the level and rigor of the high school mathematics course taken and how well the student performed in that course (Anderton et al., 2017). The same requirements generally follow for other STEM courses as well, students who decide to pursue these degrees are more prepared if high school Advanced Placement (AP) courses were taken, as the level of rigor is above regular high school courses in most cases (An & Taylor, 2015).

While other factors influence college readiness and success, multiple research studies conducted state that the use of GPA and test scores used together predict more information regarding college success then each of those factors alone (Sawyer, 2010, Scott-Clayton, 2012; Westrick, 2016). The combination of factors increases the accuracy of predicting college success (Westrick, 2016). Academic, and non-academic factors are key indicators in evaluating if students are ready to enroll in college and if students will be successful (Westrick, 2016). The main components remain to be high school GPA, SAT or ACT scores, and the academic rigor present in courses (Godfrey & Matos-Elefante, 2010; Morgan et al., 2018).

Nationwide, it has become widely recognized that receiving a high school diploma is not a clear indicator of college readiness and preparation, that indicator is a rigorous high school curriculum (Morgan et al., 2018). Courses that have high rigor incorporated into the curriculum are the most beneficial for preparing students for the requirements of college coursework (Morgan et al., 2018). With the emphasis on increasing academic rigor after A Nation at Risk called for an educational reform, thus, came the creation of the Academic Rigor Index (ARI) (Zwick, 2017). This index measured the academic intensity and challenges associated with high school curriculum and relate it to college readiness and preparedness (Austin, 2019).
The ARI related high school coursework to the first year GPA of students (Wyatt et al., 2011). Points are awards based on the courses taken in high school, if a student takes honors, AP, or dual enrollment courses the ARI increases (Wyatt et al., 2011). The ARI is not dependent on the course grade, as it is used with the high school GPA and measure college readiness by comparing the rigor of high school courses with that expected of college classes (Allen et al., 2019). Through all measurable indications by using the ARI, it remains that high rigor in mathematics courses has the strongest relationship with completing a bachelor’s degree (Allen et al., 2019).

**Rigor of College Preparation**

Preparing for the academic demands of college is a main component of college success (Kurlaender et al., 2019). In the past decade, there has been a large focus on increasing the rigor of courses in high school environments in effort to better prepare students for college (Asim et al., 2019). Students who take more challenging and rigorous high school courses have a higher opportunity to be successful in college and reach completion (Smith et al., 2017). With the increased number of students holding a desire to attend college, being prepared has become a common discussion across the nation (Hoover et al., 2018).

Studies have shown that rigor promotes academic success (Kurlaender et al., 2019). As rigorous coursework allows students to experience more advanced material such as college content (Kurlaender et al., 2019). High quality content is also directly linked to high quality instruction, thus explaining private high school curriculum contains high rigor or those schools that offer honors and AP courses (Kurlaender et al., 2019). While rigor is a known component to influence college success, studies still lack in determining what rigor looks like across multiple curriculums and disciplines (Kurlaender et al., 2019).
According to students, there is little knowledge of what to expect when entering post-secondary education, as current knowledge of college expectations is based on the amount of rigor and expectations experienced in high school (Chaudhuri, 2018). Unfortunately, grade-point averages and ranking are not a true indicator of academic success (Beattie et al., 2018). College faculty report that the range of students who are not prepared for college courses range from those who were high to low achieving in high school (Whitaker, 2016). Thus, high school experience remains the most important indicator of predicting first-year college academic behavior and success (Chaudhuri, 2018). High school is the key predictor of college success (Bettinger et al., 2013, Long et al., 2012, Howell et al., 2010). For example, the highest level of mathematics a student takes in high school has a direct relation with the likelihood of being prepared to take on post-secondary options prepared for coursework (Dougherty et al., 2017).

In the United States, the core high school mathematics curriculum is composed of one year of geometry, and two years of algebra, generally algebra 2 and pre-calculus (Orzech, 2018). The emphasis is algebra as it prepares students for the path to pre-calculus and calculus in later years (Orzech, 2018). As when student’s complete calculus in high school by senior year, it becomes an indicator of a college preparatory track and college admission (Rosenstein & Ahluwalia, 2016).

While the students who complete calculus in high school may not be at risk for needing college remedial mathematic coursework, states generally have integrated curriculum as well (Viney, 2016). The CCSS also have the option of integrated coursework, which consists of a developmental curriculum that makes connections between geometry and algebra (Viney, 2016). Integrated courses align to multiple subject areas rather than focusing on one (Asim et al., 2019). Regardless of the mathematical journey pathway, the traditional or integrated, both
designs align with some degree of post-secondary study (Asim et al., 2019). Both high and low-level classes can have rigor implementation to support academic success (Blackburn, 2018).

High school courses have the sole opportunity to prepare students for college expectations (Barnett, 2016). Despite the academic past, research supports that students will benefit from taking challenging courses in high school, even if there has been past academic struggle (Barnett, 2016). Studies support that participation and performance in rigorous high school mathematics courses link to positive educational outcomes in college and later education (Long et al., 2012).

**College Mathematics**

Mathematics is one of the most important subjects required across a wide range of college degrees (McCarron & Burstein, 2017). With mathematics being the core of science and engineering degrees, emphasizing student preparation to be successful in college mathematics classes without having to take remedial or developmental courses is ideal (McCarron & Burstein, 2017). In college across the United States, many degrees are now requiring students to pass advanced mathematics, linear algebra, and probability and mathematical statistics (Zhu, 2018). Unfortunately, there is a disconnect from high school mathematics courses to post-secondary, as very few students are prepared to take on the rigor and content of the upper courses (Burrill, 2017). Rather than entering college prepared to begin courses that count for degree attainment, there is an increase in students needing remedial coursework (Ngo, 2020). College mathematics continues to be a frustration for many students, and even more frustrating for those in developmental mathematics courses, adding another course to the academic plan (Kolodner, 2016).
The United States leads the world in the percentage of high school graduates who enroll in postsecondary education, however, it does not lead the world in students earning a college degree (Harrington et al., 2016). The lack in college readiness, especially in STEM classes such as mathematics, has a major impact on student success (Harrington et al., 2016). A national concern remains regarding the math performance of students who transition into college (ACT, 2018). Dating back to before 1998, Lewis discussed the issue of accepting students to universities with low mathematical skills, today, the concern remains as there have not been improvements (ACT, 2019). Studies also report that a more rigorous high school math curriculum shows positive outcomes for student success in college mathematics as well as overall college graduation rates (Atuahene & Russell, 2016). However, many schools still lack the rigor needed to assist students in reaching this level of success (Atuahene & Russell, 2016).

The considerable misalignment between high school mathematics course expectations and college course expectations continues to be of concern as college mathematics has direct influences on future career success (Er, 2018). With that said, education leaders give consideration into reforms on these issues. Two of the main topics regarding reforms are changing developmental mathematics and improving mathematical instruction in both high school and college environments (Hodara, 2013). This drive to increase and improve mathematics preparedness comes from one of the largest pressing educational issues in the nation, the effort to raise the number of students prepared for careers in the STEM fields (Warne et al., 2019). Unfortunately, reaching these careers is extremely difficult for those students who are not prepared for college-level coursework or have placement in remedial mathematics courses (Warne et al., 2019).
While various demographics also play a role in college readiness and math success, a key indicator of preparedness remains academic rigor (Blackburn, 2018). The first-year college GPA not only predicted by placement exam scores, but by the high school courses taken as well as the academic rigor present in those course environments (Allen et al., 2019). Academic rigor is key to assuring that students are prepared for college courses without having to take remedial courses and have the greatest possible chance at being prepared for not only college but careers post-college graduation (Allen et al., 2019).

**Remedial/Developmental Mathematics**

Each year across the nation, thousands of students enter college and universities under prepared for mathematics (Babrich, 2016). Oddly, often college mathematics is a repeat of high school mathematics courses with increased rigor when it should be higher level content (Ngo, 2020). This leads to the issue regarding developmental mathematics, which has the highest failure and withdrawal rates of all post-secondary courses (Acee et al., 2017). While mathematics is a barrier to degree attainment, placing students in remedial coursework which may essentially delay program completion had more negative effects (Zientek et al., 2020). An alarming high number of students enter needing remedial courses; however, a low number of students complete those courses, leading to more students dropping out of college or being unable to complete higher mathematics courses for degree completion (Logue et al., 2017).

For many decades, scholars have examined ways to determine if developmental mathematics in college environments are effective to student education and growth (Varner, 2018). Studies have returned a variety of findings stating that remedial coursework assists all students, even those who appear to be high achieving (Bahr, 2010), while Bettinger and Long (2008) showed that remedial coursework only helps those lower students, and Perin (2012)
showed that remedial courses negatively impact the students chances of obtaining a degree. A solid determination of the effectiveness of developmental and remedial courses does not appear to exist. However, what does remain constant, is that students are not prepared for the rigor, meaning that increased rigor in high school environments could assist in closing the gap of students needing remediation (Varner, 2018).

Ideally, remedial courses repeat material and content that should have been mastered in high school mathematics courses (Ngo, 2020). This content would not need repetition if students were actively engaged in the learning process in high school environments, and experienced rigor (Ngo, 2020). Students who are actively engaged and experience a challenging educational experience “have a greater likelihood of success in the classroom” and will more than likely continue prepared into college educational environments (Okimoto & Heck, 2015, p. 645). Being prepared for college without the need for remedial coursework is the best opportunity for college success (Bettinger & Long, 2005).

**College Entrance Exams and Dropout Rates**

The ACT and SAT are college entrance exams required for admission to nearly all four-year institutions across the nation (Hyman, 2017). As one of the main predictors of college success, the entrance exams assist in increasing student admission chances, help determine proper educational paths and assistance, as well as assists in predicting success (Branch, 2017). School systems nationwide have adopted college entrance exams such as the SAT and the ACT, making these tests the statewide accountability test (Hurwitz et al., 2015). Prior to the ACT becoming a mandatory test for college, roughly 56 percent of college bound students took the exams, leaving many students entering college with little indication of success (Hyman, 2017). After the ACT became mandatory for four-year colleges, the percentage grew to 91
percent (Hyman, 2017). In addition, some colleges also require additional placement exams to assist in deciding proper courses (Hurwitz et al., 2015).

Before students enter college, making determinations about academic ability from all test score observations are common (Branch, 2017). Higher test scores allow admittance to a wider range of postsecondary institutions (Moore & San Pedro, 2019). If a student scores average or above average, educators assume that the student is ready for college-level courses and will succeed in them (Belfield et al., 2014). If the student scores below average, the assumption is that the student needs to be in developmental or remedial courses to improve academic skills before enrolling in courses that count for a degree (Belfield et al., 2014). Two issues arise from these assumptions, as not all students who score well on exams are ready for college level mathematics, and not all students who score below average may need remedial coursework (Branch, 2017). Thus, the true indicator of college success is the amount of rigor and level of courses students experienced throughout the high school experience (Hodara & Lewis, 2017).

A major challenge with students today is the lack of academic preparation for college-level mathematics courses (Hodara, 2013). In college mathematics, first year students often drop out due to the inability to effectively handle the rigor and academic requirements and challenges expected (Jeschke et al., 2016). Often time students who drop out of the first year of college state that higher mathematics courses were too challenging to handle, and the study skills to prepare for these classes lacked (Aboltins et al., 2019). Some of the students reporting not being able to handle the rigor of the coursework also performed quite well on college entrance exams (ACT, 2019). One of the main components influencing college withdrawal rates is the lack in preparation from previous mathematics courses taken in high school, as the rigor greatly
increases as students move to college, leaving a barrier to successful completion (Villanueva-Cantillo et al., 2020).

Pertaining to mathematics specifically, those students who initially decide on a STEM major, and then later switch to a non-STEM areas of study are less likely to complete and finish a bachelor’s degree and are more likely to drop out of college than those who stayed with the initial decision (Lee & Ferrare, 2019). As soon as students start to struggle in mathematics courses or other STEM classes the option to quit appears easier than the one to seek out assistance (Lee & Ferrare, 2019). Mathematics shapes the post-secondary opportunities by being an important component of many degrees (Ngo, 2020). If students are not able to get past the mathematics courses, dropping out appears to be the only option (Ngo, 2020).

**Theoretical Framework**

The theoretical framework is one of the most important components in the dissertation research process (Osanloo & Grant, 2016). This study will explore Bruner’s Spiral Curriculum Theory with two supporting theories consisting of Merrill’s First Principles of Instruction Theory and the Folk Belief Theory. The theoretical framework will use the theories to support and guide this study through inquiry and findings.

**Bruner’s Spiral Curriculum Theory**

Bruner, a 20th century educational psychologist argues that any subject, including mathematics, could be taught to any student at any developmental stage when rigor is incorporated into the curriculum (Cowan et al., 1998). Bruner’s Spiral Curriculum Theory advocates for the scaffolding of curriculum by a continual cycle of revisiting topics, with each time increasing the rigor and difficulty to strengthen and deepen the understanding of the content (Cowan et al., 1998). Bruner (1962) states that a spiral curriculum “turns back on itself at higher
levels” (p. 13). In education, reforms and conversations continually dictate what needs to be taught in each subject at each grade level (Harden, 1999). Unfortunately, a largely neglected portion of education is any dictation regarding the construction and teaching of content to students (Harden, 1999). Increasing the complexity of topics each time throughout the school year allows students to actively recall past information, rather than learn it and forget it (Eldred, 2018).

Encouraging students to justify and build on previous material continually throughout the school year prepares students for the rigor and variation of coursework to be expected in post-secondary classes (Stylianou & Blanton, 2011). Building curriculum and structuring it from the bottom to the top while implementing rigor encourages different stages of comprehension (Brighton, 2019). Previous knowledge is important in education, as students should actively be recalling information and applying it to new ideas (Brighton, 2019). Learning concepts should connect to old information, ideas need to be hierarchical, and continually revisited with increased depth, rigor and complexity (Eldred, 2018). The focus of this research study is to analyze the implementation of rigor and how Bruner’s Spiral Curriculum Theory assists in this implementation throughout the private high school curriculum.

**Merrill’s First Principles of Instruction Theory**

Implementation of the First Principles of Instruction could be applied to any educational context (Lo & Hew, 2017). In hopes of improving student comprehension and learning, the overarching framework Merrill describes can assist in this goal (Lo & Hew, 2017). Merrill (2002) suggest that the most effective learning models are problem-centered and involve four specific phases of learning:

1) activation of prior experience
2) demonstration of skills
3) application of skills
4) integration of these skills into real-world activities

Merrill (2002, 2007) then proposed five foundational principles of instruction which incorporate the four specific phases of learning and increase student learning when used in the classroom. There is increasing evidence supporting the use of these Principles of Instruction in instructional strategies to increase learning (Gardner, 2011). The principles are as follows (Merrill, 2002):

1) **Problem-Centered**: Learning is prompted when learners are engaged in solving real-world problems.
2) **Activation**: Learning is promoted when existing knowledge and skill is activated as a foundation for new knowledge and skill.
3) **Demonstration**: Learning is promoted when new knowledge is demonstrated to the learner.
4) **Application**: Learning is promoted when new knowledge is applied by the learner.
5) **Integration**: Learning is promoted when new knowledge is integrated into the learner’s world.

Using these phases and principles to select and design effective instructional strategies such as implementing higher rigor into curriculum is beneficial (Merrill, 2007). Utilizing Merrill’s theory, activating, demonstrating, applying, and integrating past knowledge actively prepares students for the future in education (Merrill, 2007).

The principles set forth by Merrill support student learning and address what actions should be taken in education, and why those actions are necessary (Merrill & Twitchell, 1994). A strong correlation is present between the use of the principles, student satisfaction, and the
performance in class (Gardner, 2010). The relationship built by the principles offer guidance on how to assist students in learning and development (Reigeluth, 1999). Instructional principles guide educators on how to develop and teach effectively (Gardner, 2010). In this study, Merrill’s Principles will assist in guiding the development and inquiry of instructional strategies used in classrooms to assess rigor.

**Folk Belief Theory**

Curriculum rigor is a significant factor in many achievement gaps, as it has become widely studied that students are more successful when challenged in the classroom (Beard, 2018; Crouch & DeStefano, 2017). The Folk Belief Theory is one of the suggested primary causes for the achievement gap present among students in education (Torff, 2014). This theory discusses the belief that educators provide high rigorous curriculum to high-advantage students, such as those who attend private schools (Torff, 2014). For the purpose of this study, a private high school is being investigated, as high amounts of rigor are present in environments that are considered college-preparatory high schools. Research by Warburton and Torff (2005) discovered that in high advantaged schools, teachers utilize rigor and higher critical thinking skills which is essential for all students to have.

A common place for the rigor gap is among private and public schools, as teachers’ beliefs about the learning ability of students from a variety of socioeconomic statuses play a role in determining how instruction takes place and what happens in the classroom (Anders & Evans, 2019). Researchers found that many teachers employ a more rigorous curriculum in those schools of high socioeconomic status or with students who pay-tuition at private schools, as generally private schools are college preparatory environments (Torff & Murphy, 2020). While it is known that private schools have a more challenging and rigorous curriculum, research
regarding how teachers create rigorous environments and the types of instructional strategies used to assure rigor is still missing (Basilio, 2018). Investigating the rigor in the private school of study will potentially assist in minimalizing the rigor gap, and encouraging the movement towards academic rigor for all students in all schools.

**Summary**

Included in this chapter was an inclusive review of the literature regarding historical perspectives, the implementation of rigor and the effects on mathematic instructional strategies, rigor, and college readiness. Chapter three will outline the methodology of the study. Chapter four will present the findings of the investigation. To conclude, Chapter five will present the conclusions of the inquiry.
CHAPTER III

METHODOLOGY

The purpose of this qualitative study was to explore the perspectives of high school mathematics teachers and administrators regarding the implementation of rigor into pedagogies that prepare high school students for college math readiness. Understanding the lived experiences of mathematics faculty with implementing rigorous instructional strategies was essential for the researcher to understand the role rigor plays. Chapter three will present research questions, rationale for the research design, research questions, setting, sampling, selection of participants, the role of the researcher, instrumentation, data collection, data analysis, and ethical considerations.

Research Questions

Three research questions guided this qualitative study:

**RQ1:** How do administrators and teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

**RQ2:** How do administrators and mathematic teachers implement and encourage rigor in classroom instruction?

**RQ3:** What are the foundational concepts that administrators and mathematics teachers use to assess college readiness of high school students?

Qualitative Approach

This researcher used a qualitative approach in its exploration of perspectives from high school mathematics teachers and administrators at a private high school in southeast Minnesota. Qualitative research assists the researcher in comprehending unique areas of inquiry as well as
understanding how and why specific occurrences develop in educational settings (Yardley et al., 2019). The ability to study lived experiences of participants contributes valuable data and perceptions to the study.

Qualitative research is appropriate for interpreting personal experiences and narratives to comprehend a problem in an environment (Creswell & Creswell, 2018). With concrete interpretations from the experiences of participants, a qualitative study assists in sharing valuable information regarding the phenomenon under study (Crossman, 2020). The thoughts and experiences of the participants provide valuable contributions to the study (Creswell & Creswell, 2018). Qualitative research methodologies are significant for studies that require careful analysis of acquired information and data (Cohen et al., 2013). Specifically, in this study, the qualitative approach is ideal due to the decision to explore phenomena of teaching experiences of high school mathematics teachers.

**Phenomenological Design**

A qualitative phenomenological method is desired when the researcher wishes to understand the essence of human experiences regarding a phenomenon and is interested in the interpretation of experiences (Creswell & Creswell, 2018). The phenomenological design consists of exploring, discovering and examining human points of view and experiences to understand the meaning of the phenomenon (Englander, 2012). In this study, the individuals teach at a college-preparatory high school where academic rigor is highly valued and expected; the experiences of these teachers will contribute to the study. The administrators at this college-preparatory high school oversee and ensure the implementation of rigor in curriculum and will contribute to the study by providing valuable perspective from an administrative viewpoint.
Rationale for the Method

Qualitative research provided the researcher with an understanding of a topic from the perspective of participants (Rosenthal, 2016). Phenomenology is an approach that focuses on similarities and differences of the lived experiences in a group of participants. Data collected is composed of a complete analysis and significant knowledge of participants’ views relating to the research topic (Creswell & Plano Clark, 2007). The research intends to assist in understanding participants’ lived experiences of a phenomenon (Sun et al., 2016). Researching how teachers and administrators view mathematic instructional rigor and the results on mathematics college readiness attempt to provide the researcher with valuable information to accomplish the study.

Research Setting

The setting for this study was a southeastern Minnesota city with a population of 120,000 people, located in a metropolitan area having an estimated 220,000 people. Four of the largest ethnic groups in the city of study consist of the following: 75% White (Non-Hispanic), 7.7% Black or African American, 7.8% Asian, 5.9% Hispanic (City of Study, 2020). The city was established in 1854 and has been the main location of one of the largest hospitals in the United States. The 54.75 square miles that the city covers houses major companies, retail stores, manufacturing centers, and tourist attractions. Also, of note, 17.0% of households speak a language other than English. The median age in the city is 35 years old, with 24.8% of the population being under the age of 18, 8.3% between 18 and 24, 29.4% between 25 and 44, 24.8% are from 45 to 64, and 12.7% 65 years of age and older. The gender makeup of the city of study is 48.4% male and 51.6% female. The median household income according to the American Community Survey in 2015 was $68,023 with an average household size of 2.42 and the average family size of 3.04. Locally, a large hospital employs roughly 35,000 people, with
the next highest two employers only having around 3,000 employees. Table 1 illustrates ethnic, age, and gender demographics described above.

Table 1

Demographics of the Southeastern Minnesota City

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>75%</td>
</tr>
<tr>
<td>Black or African American</td>
<td>7.7%</td>
</tr>
<tr>
<td>Asian</td>
<td>7.8%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>5.9%</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>3.1%</td>
</tr>
<tr>
<td>American Indian and Alaska Native</td>
<td>0.4%</td>
</tr>
<tr>
<td>Native Hawaiian and Other Native Pacific Islander</td>
<td>0.1%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>0-17</td>
<td>24.8%</td>
</tr>
<tr>
<td>18-24</td>
<td>8.3%</td>
</tr>
<tr>
<td>22-44</td>
<td>29.4%</td>
</tr>
<tr>
<td>45-64</td>
<td>24.8%</td>
</tr>
<tr>
<td>65 and older</td>
<td>12.7%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48.4%</td>
</tr>
<tr>
<td>Female</td>
<td>51.6%</td>
</tr>
</tbody>
</table>

The large geographic area comprises multiple school districts consisting of one large public-school district and several smaller private school districts. The area public schools are composed of 17 elementary schools, four middle schools, three high schools, and one alternative learning school. The district has over 2,000 employees and 18,000 students, with a graduation rate of 85%. The private district of study, where all students pay tuition to attend, consists of six schools ranging from preschool to high school consisting of an early learning preschool, two
preschools through 5th grade schools, one preschool through 8th grade school, one middle school for grades six through eight, and one high school. The six schools encourage students to develop spiritually, socially, emotionally and academically through the school experience. As accredited institutions, the district is continually seeking improvements through a five-year cycle by collecting data through satisfaction surveys, goal setting, and site visits from an accreditation team. This accreditation team challenges the school to improve specific indicators to ensure academic growth is one of the main goals of the environment. The educational setting is one of the top 25 private schools in the state, as it is a college-preparatory school with a graduation rate of 100%. Roughly 90% of students continue to attend four-year colleges to pursue undergraduate degrees, while 100% of students seek some level of post-secondary educational pathway. The high school of study consists of 40 faculty members, with roughly 400 students in grades 9 through 12. The private school of study consists of 71.3 percent white students, and 28.7 percent minority, falling just below the state average of 33.2 percent minority in schools. Table 2 below shows the demographic comparisons for the school of study and state averages. According to Minnesota, which sets the goal of a 90% graduation rate for all subgroups, every subgroup is underachieving, Asians are the closest subgroup statewide to meeting the graduation goal. However, the school of study has already met the statewide goal and overachieved with a 100% graduation rate for all students.

The mission, according to the school’s website, is to create college-ready students who are prepared to take on the rigor of four-year college coursework. The private school offers a challenging curriculum to prepare students for post-graduation college education, including offering ten advanced placement (AP) courses. Regarding nationally recognized exams such as the ACT, student achievement scores are significantly higher than those of local schools and
national and state averages. Graduation requirements, as well as GPA requirements, are higher than those of area schools to maintain status as a college preparatory environment. In addition, the school of study does not allow students to re-take tests, and instructors do not accept late work after five school days have passed. At the end of the late work period, if work is not submitted, the teacher would place a zero in the gradebook. Unique scheduling is used to mimic a college environment, where there are days that students do not meet in the classroom and have the opportunity to meet in office hours with faculty and teachers or go to quiet study, the library, or the commons. Academics come first in this environment, and the student to faculty ratio of 12:1 assures plenty of time for support. Class sizes are approximately 20 students to allow meaningful student-teacher interactions and support.

Table 2

Demographics and Graduation Rate Comparison: School of Study vs. State Averages

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>School of Study Demographics</th>
<th>School of Study Graduation Rate</th>
<th>High School State Average Demographics</th>
<th>High School State Average Graduation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>71.3%</td>
<td>100%</td>
<td>64.7%</td>
<td>82%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12%</td>
<td>100%</td>
<td>10.1%</td>
<td>67%</td>
</tr>
<tr>
<td>Black or African American</td>
<td>9%</td>
<td>100%</td>
<td>10.6%</td>
<td>67%</td>
</tr>
<tr>
<td>Asian</td>
<td>7.2%</td>
<td>100%</td>
<td>7.0%</td>
<td>87%</td>
</tr>
<tr>
<td>American Indian and Alaska Native</td>
<td>0%</td>
<td>-</td>
<td>1.7%</td>
<td>51%</td>
</tr>
<tr>
<td>Native Hawaiian and Other Pacific Islander</td>
<td>0%</td>
<td>-</td>
<td>0.1%</td>
<td>61%</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>0.5%</td>
<td>100%</td>
<td>5.7%</td>
<td>72%</td>
</tr>
</tbody>
</table>
**Sampling Population**

Sampling is the process of choosing a small part of a population to represent the whole (Naderifar et al., 2017). When the goal of a research study is to gain insights into a phenomenon or individuals, a qualitative sampling method is encouraged as the researcher is allowed to select individuals who increased the opportunity to understand the phenomenon (Onwuegbuzie & Leech, 2007). In this case, the researcher chose administrators and mathematic teachers who currently work and teach at the private school of study. The experiences of the participants were valuable to the researcher in proceeding through this study. Therefore, when seeking data about a particular phenomenon, purposeful sampling is ideal (Tuckett, 2004).

**Purposeful Sampling**

Purposeful sampling is frequent in qualitative research for selecting and identifying subjects related to the phenomenon under study (Palinkas et al., 2015). A researcher employing purposeful sampling carefully chooses participants who will contribute relevant information pertaining to the study (Maxwell, 2012). Choosing participants who will provide data that will inform answers to research questions is a critical component in qualitative research designs (Maxwell, 2012).

**Sample**

The sample represents the three high school administrators and five current high school faculty members who teach in the mathematics department. Creswell and Creswell (2017) assert qualitative research generally has small sample sizes, stating that phenomenological studies involve typically three to ten participants. Due to the small school environment, all administrators and all five of the teachers in the mathematic department were asked to participate. Qualitative research relies on small numbers in attempts to study depth and detail.
pertaining to a phenomenon (Tuckett, 2004). The five high school mathematics teachers teach a variety of classes such as low-level, regular, honors, and AP courses. A strictly professional relationship between the researcher and participants was maintained to avoid any conflicts of interest.

**Selection of Participants**

Three high school administrators and five high school mathematics teachers, with a variety of educational backgrounds were asked to participate. Education of participants range from Bachelor of Science degrees to Masters degrees. All participants teach a full course load at the school of study or are full-time administration faculty. The high school teachers teach courses ranging from lower to advanced mathematic courses. Exploring the phenomenon of administrative faculty and mathematics teachers in implementing rigor in instruction to increase the college readiness of high school students requires that participants currently teach or work in a high school environment. These faculty are critical informants, as they have experience to provide information-rich perspectives on the phenomenon under study (Suri, 2011). The selection of participants is dependent upon availability and willingness to express and share lived experiences (Palinkas et al., 2015). The investigator will maintain a professional relationship with participants to avoid any conflicts of interest. Table 2 below reflects the demographics of the participants that were asked to participate.
### Table 3
Demographics of participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Race</th>
<th>Age</th>
<th>Years Taught</th>
<th>Classes Taught</th>
<th>Classes Previously Taught</th>
<th>Educational Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Administrator - Female</td>
<td>White</td>
<td>42</td>
<td>20</td>
<td>AP Literature</td>
<td>AP Literature</td>
<td>Master’s in Educational Leadership</td>
</tr>
<tr>
<td>A2</td>
<td>Administrator - Male</td>
<td>White</td>
<td>53</td>
<td>25</td>
<td>History</td>
<td>History</td>
<td>Master’s in Educational Leadership</td>
</tr>
<tr>
<td>A3</td>
<td>Administrator - Female</td>
<td>White</td>
<td>61</td>
<td>35</td>
<td>Study Skills-Special Education</td>
<td>Study Skills</td>
<td>Master’s in Educational Leadership</td>
</tr>
<tr>
<td>T1</td>
<td>Male</td>
<td>White</td>
<td>34</td>
<td>8</td>
<td>Geometry, Pre-Calculus</td>
<td>Pre-Calculus, Geometry</td>
<td>Bachelor’s in Mathematics</td>
</tr>
<tr>
<td>T2</td>
<td>Female</td>
<td>White</td>
<td>27</td>
<td>5</td>
<td>Geometry, College Math</td>
<td>College Math, Algebra 2, Geometry, Study Skills, Algebra 1</td>
<td>Master’s in Education</td>
</tr>
<tr>
<td>T3</td>
<td>Male</td>
<td>White</td>
<td>29</td>
<td>8</td>
<td>Calculus, AP Calculus, Pre-Calculus</td>
<td>Calculus, AP Calculus, Pre-Calculus, Algebra 2</td>
<td>Bachelor’s in Mathematics</td>
</tr>
<tr>
<td>T4</td>
<td>Female</td>
<td>White</td>
<td>29</td>
<td>5</td>
<td>Algebra 2, Pre-Calculus, Statistics</td>
<td>Geometry</td>
<td>Master’s in Education</td>
</tr>
<tr>
<td>T5</td>
<td>Female</td>
<td>White</td>
<td>43</td>
<td>15</td>
<td>Geometry, College Math, Calculus</td>
<td>Algebra I</td>
<td>Master’s in Education</td>
</tr>
</tbody>
</table>

**Role of the Researcher**

In qualitative study, the researcher is the main instrument for data collection (Creswell & Creswell, 2018; Denzin & Lincoln, 2003). Maintaining integrity is a main component of the
process, as aiming for a high-quality study is essential (Yin, 2015). Through the human instrument, by means of interviews and conversations, collection of data takes place (Simon, 2011). For this study, data collection methods were document review and two methods of interviews consisting of one-on-one interviews, as well as focus group interviews. Through asking key questions, interviews encouraged in-depth conversations forming follow-up questions resulting in additional dialogue (Simon, 2011).

**Data Collection**

Before entering the environment to collect data, the researcher takes careful consideration of the data collection methods used (Creswell & Creswell, 2018). The researcher has chosen to use document review, one-on-one interviews, and focus group interviews.

Data collection of the study cannot begin until obtaining approval from the Institutional Review Board (IRB). The purpose of the IRB is to protect participants and assess the risk of being involved in the study (Creswell & Creswell, 2018). Filing the IRB forms allows procedures and information regarding participants and the research to be examined and reviewed (Creswell & Creswell, 2018). Participants were required to sign an informed consent form prior to providing any data (Creswell & Creswell, 2018).

**Data Collection Methods**

In a qualitative phenomenological study, the goal is to examine and describe the experiences of a phenomenon described by the participants of the study (Creswell & Creswell, 2018). In attempts to increase reliability and validity, triangulation was used. Data sources used will include documents and two different types of interviews, one-on-one, and focus groups. Interviews were recorded to ensure the experiences shared are transcribed accurately.
**Triangulation**

Triangulation was used to build trustworthiness in research studies (Mandal, 2018). Using triangulation increases the reliability and validity of the study (Stavros & Westberg, 2009). Triangulation consists of using multiple data collection methods concerning the same research topic to enhance and cross-check results (Fusch et al., 2018). Through triangulation, depth is added to the data that is collected, which is an essential concept in qualitative studies (Fusch et al., 2018). Biases are also limited through triangulation, as it offers more than one opportunity for perspectives to be shared. Figure 1 below illustrates data collection methods the researcher has decided to employ for the study.

**Figure 1**

*Triangulation of Data Collection Methods*

![Triangulation Diagram](image)

**Document Review**

Document review is a technique used to investigate existing sources of information that may be valuable to the research study (Hanson et al., 2011). Analyzing documents is a valuable component of triangulation, especially in the study of a phenomenon (Bowen, 2009). Document review is a convenient, easily accessible way to gain data with which participants are familiar; it
also allows the researcher to learn components that may be useful in following data collection methods (Creswell & Creswell, 2018).

Examining school documents such as the schools most recent strategic plan and faculty handbook the researcher obtained data regarding course constructs and rigor embedded into the curriculum and school. In these documents, the school of study has requirements the teachers have to meet as far as the number of assessments given per semester, grading scales, and graduation requirements, information was gathered from these documents to contribute to the study. In addition, examining the states most recent career and college readiness guide was also reviewed. Reviewing these class and state components provided insight to the classroom, as document review was conducted through considering the context in which it was created and why (Letts et al., 2007). Documents were reviewed looking for commonalities, themes, and the influence of rigor on the structure and creation. This review will take place prior to interviews as it could potentially provide background information regarding classroom policies, set-up and procedures.

**Interviews**

Interviews, one of the most common forms of data collection, have been a dominant technique in qualitative research for many years (Opdenakker, 2006; Bullock, 2016). Interviews were administered face-to-face, over the telephone, and on online web conferencing software. Semi-structured interviews will comprise open-ended questions (Creswell & Creswell, 2018). A beneficial component of semi-structured interviews is the synchronous setting, which renders time and place of the meeting irrelevant (Patton, 2016). No significant delay exists in gaining the information needed, as conversations occur without waiting days for a response
Unstructured interviews allow participants to provide extended responses, which is highly beneficial to informing the study (Patton, 2016).

**One-on-One Interviews**

Method two is one-to-one Interviews that take place when the researcher conducts face-to-face interviews or telephone interviews with participants (Creswell & Creswell, 2018). The researcher will conduct one-on-one in-depth interviews with the administration to collect data on rigor strategies and the effects they have on college readiness as it pertains to the school. One-on-one interviews are also considered one of the most reliable and valid research methods to use (Salkind, 2003). Real-time responses are valuable to the researcher. This researcher will conduct individual interviews to obtain data on the perceptions and feelings of participants regarding the phenomenon under study (Salkind, 2003).

**Focus Group Interviews**

Focus group interviews take place when the researcher conducts interviews with a few members to collect collective knowledge about experiences, strategies, and decisions (Creswell & Creswell, 2018). Focus groups create a more natural environment than those of one-on-one interviews, as it reflects a meeting or discussion setting (Dilshad & Latif, 2013). The comments and contributions of one member may spark conversation or feedback from another, continually keeping participants engaged in the session, contributing substantial information (Dilshad & Latif, 2013). Open-ended questions and follow-up questions allowed the researcher the ability to elicit valuable data and perspectives related to the phenomenon under study. In this study, the mathematics faculty participated in the focus group interviews to contribute and share collective knowledge on classroom processes that contain rigor and the views on preparing students for college mathematics.
Data Analysis

Data analysis is an important component of qualitative research (Creswell & Creswell, 2018). While the researcher is interviewing participants, analysis of previous interviews may be taking place, as any notes and memos assist in the organization and structure for the future final report (Creswell & Creswell, 2018). Qualitative data require the coding of the information provided by participants. Analyzing qualitative data is a long process needing careful guidance. The data analysis process consists of the five steps described by Creswell and Creswell (2018).

1) Organize and prepare the data for analysis: transcribing the interviews, conducting document review, typing up notes and memos, and arranging data to get organized.

2) Read or look at all the data: gain a general sense of the information and reflect on the meanings.

3) Start coding all the data: take the text and label it into categories.

4) Generate a description and themes: generate a description and categories or themes for analysis.

5) Representing the description and themes: describe how the themes will be represented in the narrative.

Analyzing data is one of the most critical components of the qualitative research process (Leech & Onwuegbuzie, 2007). In qualitative studies, data analysis brings meaning to the study (Hatch, 2002). Through examining documents and conducting interviews, the researcher will sort and make meaning of the collected data. While there is no sole correct way to analyze qualitative data, a rigorous analysis process presents impactful perspectives and themes (Raskind et al., 2019; Saldana & Omasta, 2018). Because qualitative research assists the researcher in understanding a phenomenon, data analysis helps bring meaning to the data set (Lester et al.,
Additionally, since qualitative data analysis is nonlinear, steps to analyze data do not take place in order; as such the investigator will use a phased protocol to uncover themes (Lester et al., 2020). Thus, thematic analysis best suited this research study.

**Limitations of the Study**

Every study, even if exceptionally constructed, has a set of limitations that require attention (Simon & Goes, 2013). Limitations are constraints of a study that are beyond the researcher’s control, which could potentially affect the outcome of the research study (Simon & Goes, 2013). In a qualitative research study, limitations support validity and reliability (Simon & Goes, 2013). Through a statement of the limitations of the research study, the researcher can assist others in generalizations and how the study may be applied to other situations and people (Creswell, 2005). While limitations can decrease validity, disclosing the variables make the study reliable (Smith, 2020).

Limitations of this study are the truthfulness of the answers received by the participants and the willingness of the participants to be involved in the study. The researcher was unable to assure that participants provided trustworthy or valid information (Patton, 2016). The participants may withdraw from the study at any point. The qualitative design of this study has the intention to seek out genuine perspectives from the participants; however, the researcher cannot control honesty of the participants in disclosure of experiences.

**Delimitations of the Study**

Delimitations are elements controlled by the researcher (Simon, 2011). This study was delimited to one private school district in Minnesota. Participation in this study was delimited to high school mathematics teachers who have had at least two years of teaching experience in a
private, college-preparatory environment. A small sample size was used to gain in-depth perspectives and understanding of the phenomenon of study.

**Anticipated Problems**

This research study was conducted during a global pandemic. Thus, as schools move from face-to-face instruction to online instruction, the workload of teachers will increase. Therefore, the willingness and time teachers had to participate lacked. Interviews that were planned to take place face-to-face with the participants were forced to take place online through web-conferencing platforms. The researcher assured that any face-to-face communications were safe and had the ability to take place socially distanced to protect individual health.

**Procedures**

The procedures for this research study were conducted through the following steps:

1) Presented an oral defense of the dissertation proposal to the chair and committee members in the fall of 2020.

2) Obtained permission from the school the research study took place. Approval was given by school officials and administration prior to contacting participants. The administration and officials were briefed on the general idea of the study.

3) Requested research study approval from the IRB as well as Winona State University, the school which the researcher is attending.

4) Contacted desired participants and obtained willingness to participate in the study with full disclosure.

5) Conducted interviews as well as requested documents for review. Interviews were conducted upon availability in a timely manner.

6) Analyzed, transcribed, and coded the data in attempts to find themes.
Ethical Considerations

Ethical issues occur in studies; thus, researchers need to protect participants and develop trust with them by promoting integrity (Creswell & Creswell, 2018). This study followed the guidelines established by the IRB and respect all human subjects participating. Therefore, the research process required that participants sign an informed consent form and understand the ability to leave the study at any given point. Participants were also given an overview of the research and an explanation as to how participation is strictly voluntary. Participants were notified of any risks that may be present, no matter how minimal the risks may seem. Other documents provided to participants included a risk statement, the right to cease participation at any point, as well as any information taken during any of the data collection methods. Consent forms were signed before any participation in the study is allowed. The researcher had no conflict of interest or prejudices pertaining to the study.

Proper approval to conduct research in the desired educational setting was acquired through communications with administration and school officials. Presentation of the study and what was expected of participants was presented to the administration in attempts to be transparent. At any point, the administration may check the status of the study. At no point in the study did the researcher display unethical behavior or cause harm to the subjects.

Information provided was protected and secured throughout the study. Documents and data collected was stored in a safe at the researcher’s home or locked in a desk. Contents of the interviews and documents collected were only shared with the committee members and chair. After completion of the study and final defense, all data and materials pertaining to this study will continue to be locked in the researchers safe and shredded after five years from the completion of the study.
Timeline for Implementation

In attempts to conduct the research study in a timely manner, the following is the anticipated timeline for completion. The oral defense presenting the proposed research took place in fall of 2020. Following the oral defense and pending IRB approval, data collection took place during the remainder of the fall semester and early in the spring semester. Data analysis took place approximately in February of 2021, with Chapters IV and V being completed after data was analyzed and approved by the committee chair and committee. The final defense took place in April of 2021.

Summary

Chapter three provided the methodology of the research study. The qualitative research study used a phenomenological approach to explore mathematic teacher’s perceptions of rigorous mathematical instructional strategies and the effects on college student readiness. Chapter four will contain the results and findings of the performed qualitative, phenomenological study.
Chapter 4

FINDINGS

The purpose of this qualitative study was to explore the experiences of private high school administrators and mathematics teachers on best practices in mathematical instructional strategies and the role rigor plays in improving college readiness. Chapter four introduces the findings of the research conducted through one-on-one interviews, focus groups, and document review, with identifiable key themes. The chapter also presents a restatement of the problem, research questions guiding the study, a review of the research design, reliability, and an overview of participants involved. Presented are four emergent themes derived from individual interviews, focus groups: (a) Importance of Productive Struggle in Mathematic Instruction; (b) Necessary Balance of Conceptual Understanding with Skill Acquisition; (c) Connection of Continuous Assessment to Content Mastery and (d) Variation and Customization of Instructional Practices. In addition, the review of documents was conducted, and the results and data are also included.

Restatement of the Problem

The United States emphasizes the importance of finishing high school and being mathematically literate to enter college (Cogan, Schmidt & Guo, 2019). Minnesota strives to reach a statewide graduation rate of 90% by 2025 with no subgroup below 85% (MDE, 2020). The problem is that limited research is present on the implementation of meaningful instructional strategies in high schools to achieve these goals (Thompson et al., 2016). School systems are known nationally for a “lack of focus on rigorous academic standards and its effects on academic achievement” (Sims, 2019, p. 10).

Stakeholders, policymakers, and educators voice concerns yearly regarding the college readiness of students leaving high school and the process to assure the mastery of necessary
skills and knowledge to succeed successfully in post-secondary options (Edmunds et al., 2017). Research shows a link between student achievement and strategic classroom instruction (Allen, Mattern & Ndum, 2019; Perdue, 2019). Nonetheless, studying current instructional strategies in academically motivated high schools allows insight to use instructional strategies promoting college readiness (Graham & Perin, 2007). The need to examine the implementation of demanding content in the curriculum is essential as students are not prepared to take on undergraduate study (ACT, 2019). The school district of study provided an insight to the instructional curriculum, rigor, and standards required to assist in continually preparing students who score above the national and state ACT averages, graduate 100% of students, and academically prepare students for post-secondary coursework and success (School of Study, 2020).

**Research Questions**

Data collected was used to answer the following research questions:

**RQ1:** How do administrators and teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

**RQ2:** How do administrators and mathematic teachers implement and encourage rigor in classroom instruction?

**RQ3:** What are the foundational concepts that administrators and mathematics teachers use to assess college readiness of high school students?

**Review of the Research Design**

A qualitative design employing a phenomenological approach allowed the researcher to explore a common experience that administrators and mathematics teachers encounter at a private school. The research design provided opportunity to gain understanding
into the human experiences of those interviewed as pertaining to instructional strategies and rigor in private school environments and the influence on improving college mathematic readiness. This section describes the type of research design employed and the rationale for selection. The collection of data took place through one-on-one interviews and focus groups, which were conducted in January of 2021, and document review of Minnesota Career and College Readiness Resource Guide, the school of study’s strategic plan, the faculty handbook, and classroom documents which was also conducted in January of 2021.

**Qualitative Approach**

This research study used a qualitative approach in its exploration of perspectives from high school mathematics teachers and administrators at a private high school in southeast Minnesota. Qualitative research assists the researcher in comprehending unique areas of inquiry as well as understanding how and why specific occurrences develop in educational settings (Yardley et al., 2019). The ability to study lived experiences of participants contributes valuable data and perceptions to the study.

Qualitative research is appropriate for interpreting personal experiences and narratives to comprehend a problem in an environment (Creswell & Creswell, 2018). With concrete interpretations from the experiences of participants, a qualitative study assists in sharing valuable information regarding the phenomenon under study (Crossman, 2020). The thoughts and experiences of the participants provide valuable contributions to the study (Creswell & Creswell, 2018). Qualitative research methodologies are significant for studies that require careful analysis of acquired information and data (Cohen et al., 2013). Specifically, in this study, the qualitative approach is ideal due to the decision to explore phenomena of teaching experiences of high school mathematics teachers.
**Phenomenological Design**

A qualitative phenomenological method is desired when the researcher wishes to understand the essence of human experiences regarding a phenomenon and is interested in the interpretation of experiences (Creswell & Creswell, 2018). The phenomenological design consists of exploring, discovering and examining human points of view and experiences to understand the meaning of the phenomenon (Englander, 2012). In this study, the individuals teach at a college-preparatory high school where academic rigor is highly valued and expected; the experiences of these teachers will contribute to the study. The administrators at this college-preparatory high school oversee and ensure the implementation of rigor in curriculum and will contribute to the study by providing valuable perspective from an administrative viewpoint.

**Rationale for the Method**

Qualitative research provides the researcher with an understanding of a topic from the perspective of participants (Rosenthal, 2016). Phenomenology is an approach that focuses on similarities and differences of the lived experiences in a group of participants. Data collected is composed of a complete analysis and significant knowledge of participants’ views relating to the research topic (Creswell & Plano Clark, 2007). The research intends to assist in understanding participants’ lived experiences of a phenomenon (Sun et al., 2016). Researching how teachers and administrators view mathematic instructional rigor and the results on mathematics college readiness attempt to provide the researcher with valuable information to accomplish the study.

**Individual Interviews**

Three administrators participated in individual interviews through a web-based conferencing software. Real-time responses collecting the perceptions and feelings of the participants regarding the phenomenon under study are valuable to the researcher (Salkind,
2003). The conduction of interviews took place online for convenience purposes as well as to limit face-to-face interaction during the Coronavirus pandemic that was ongoing during the study. Interviews took place in January 2021 during the course finals week for semester one at the college preparatory high school, thus, the researcher did not want to inconvenience administrators in any way.

All three administrators agreed to participate and gave consent to participate in the study. Participants were provided with an interview protocol form and an email link to the online questionnaire containing demographic questions regarding educational background as well as specifics of questions to be asked. The administrators responded to all questions asked and were cooperative in participating.

**Focus Group Interviews**

Five high school mathematics teachers were chosen and asked to participate in the focus group for this study which took place in January 2021 during the Coronavirus pandemic. Thus, the focus group was conducted through a web-conferencing platform to maintain social distancing guidelines. Focus groups create a relaxed environment mimicking a meeting or discussion where comments and contributions develop off previous questions (Dilshad & Latif, 2013). All five mathematics teachers participated and answered all the questions based on perspectives and experience teaching in the profession. Participants were given the informed consent form and were provided with a focus group protocol form. The focus group was recorded and transcribed for accuracy.

**Document Review**

The last method of analysis used in this qualitative study is document review. As a valuable component of triangulation, document review is a convenient and easy way to gather
data which allows the researcher access to information participants are familiar with (Bowen, 2009; Creswell & Creswell, 2018). The investigator interpreted three types of documents: classroom teacher documents, administrator and school documents, and state documents. A brief overview of each type of document appears in this section. Examining the Minnesota Career and College Readiness Resource Guide, the school of study’s strategic plan, the faculty handbook, and classroom documents provided perspectives valuable to this study.

The first document is the Minnesota Career and College Readiness Resource Guide which aims to organize the indicators that measure career and college readiness as a resource for schools to improve outcomes for students and close achievement gaps. The guide attempts to assist schools on the path to compiling and evaluating their own school data to support accountability, academic progress, and student success (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Second, is the school of study’s strategic plan, which is a summary of the steps to achieve an environment that develops the spiritual, social, emotional, and academic growth of students in the facility. The strategic plan encompasses the goals and objectives of the school emphasizing the importance of the catholic identity, academics, financial performance, as well as stakeholder engagement. Third, is the faculty handbook which sets forth the academic requirements set by administrators that teachers and staff need to follow to improve student achievement, engagement, and academic experience. Last, is classroom documents from individual teachers that contain components regarding grading scales, mathematic curriculum, and instructional strategies.

**Evaluation and Analysis of Qualitative Data**

Data analysis is an important component of qualitative research (Creswell & Creswell, 2018). While the researcher interviews participants, analysis of previous interviews may be
taking place, as any notes and memos assist in the organization and structure for the future final report (Creswell & Creswell, 2018). Qualitative data require the coding of the information provided by participants. Analyzing qualitative data is a long process needing careful guidance. Through examining documents and conducting interviews, the researcher sorted and made notes regarding the collected data. While there is no sole correct way to analyze qualitative data, a rigorous analysis process presents impactful perspectives and themes (Raskind et al., 2019; Saldana & Omasta, 2018). Because qualitative research assists the researcher in understanding a phenomenon, data analysis helps bring meaning to the data set (Lester et al., 2020). Additionally, since qualitative data analysis is nonlinear, steps to analyze data do not take place in order; as such the investigator used a phased protocol to uncover themes (Lester et al., 2020). Thus, thematic analysis best suited this research study.

**Trustworthiness**

Trustworthiness refers to the level of confidence in data which supports the quality of the study (Pilot and Beck, 2014). While trustworthiness is necessary for qualitative studies, criteria to assure a study is trustworthy varies (Connelly, 2016). Guba and Lincoln (1994) state that a robust qualitative study must meet the requirements of credibility, dependability, confirmability, transferability, and authenticity.

**Credibility.**

The credibility of the study is the most critical criterion (Polit & Beck, 2014). Assuring the study and finding are truthful and confident assures credibility in a qualitative study (Pilot & Beck, 2014). Credibility is accomplished when the researcher checks and verifies data multiple times to ensure no mistakes take place.
**Dependability.**

Dependability focuses on consistency across the study from start to end, data collection, and analysis (Kyngas et al., 2020). In attempts to maintain high dependability, the researcher will have a solid understanding of the theoretical framework and phenomenon to construct a study that other researchers can follow (Kyngas et al., 2020). Utilizing peer examination will strengthen the dependability of the study.

**Confirmability.**

Confirmability measures how the study is supported by the data (Lincoln & Guba, 1985). Connecting the data and the results are an important aspect of the study. The researcher must identify if the findings are formed from the data collected from participants or if the findings reflect and form of bias of the researcher (Kyngas et al., 2020). Confirmability is best built through the triangulation of data (Mandal, 2018).

**Transferability.**

Transferability describes how relevant and applicable the research findings will be in other fields and research (Lincoln et al., 1985). Being transparent in the research process and obtaining results is critical in assuring transferability (Kyngas et al., 2020).

**Authenticity.**

Authenticity is strengthened when a researcher includes multiple citations that are able to make connections between the results and data (Kyngas et al., 2020). The researcher will show a range of realities through being truthful and fair.

**Validity.**

Validity in terms of research means the researcher chooses specific procedures to check for accuracy in the findings (Creswell & Creswell, 2018). Validity is also defined as a strength
in qualitative research, as validity determines if the results of the study are accurate from the perspective of the researcher, the participants, and the readers (Creswell & Miller, 2000). Assuring that a research design is trustworthy, authentic, and credible is one of the keys to a substantial research study (Creswell & Miller, 2000).

**Reliability.**

Reliability is a concept in a qualitative research study that assists in developing a quality study (Golafshani, 2003). Validity and trustworthiness also play a role in the reliability, as a robust research study considers all aspects (Golafshani, 2003). With reliability being one of the main components of a study, the importance of a stable, consistent, and accurate researcher is essential (Souza et al., 2017). Reliability is vital in qualitative studies and necessary to assure the reader the study is worth reading (Cypress, 2017).

**Thematic Analysis**

Thematic analysis identified patterns across qualitative data (Braun et al., 2019). Commonly used in education, thematic analysis uses multiple phases to analyze data (Lester et al., 2020). These phases assist the researcher in making sense of data. Thematic analysis is useful when sorting data is necessary to determine relationships and themes of information gathered from participants (Lester et al., 2020). The phases used in thematic analysis will be the following, presented by Lester (2020):

1) Preparing and organizing the data for analysis.
2) Transcribing the data.
3) Becoming familiar with the data.
4) Memoing the data.
5) Coding the data.
6) Moving from codes to categories and categories to themes.

**Preparing and Organizing the Data for Analysis.**

One of the first steps in qualitative studies is to prepare and organize data, so it is presented in a way to be analyzed. Assuring that all documents are collected and saved in a safe and proper place is essential to maintaining the integrity of the data (Lester et al., 2020). Making sure data is all uploaded and labeled correctly prepares the importation of data into software for further analysis.

**Transcribing the Data.**

Digital technology has paved the way for recording and conducting qualitative interviews (Fernandez & Griffiths, 2007). Verbatim transcripts were used to accurately record the conversations and discussions taking place with the participants. The researcher transcribed the data personally to become familiar with the data set. This familiarity strengthened and deepened the researcher’s understanding of the perspectives (Lester et al., 2020).

**Becoming Familiar with the Data.**

Becoming familiar with data is essential in the data collection process (Lester et al., 2020). Understanding the data, once organized and transcribed, is helpful in proceeding to a more detailed analysis. Hence, organizing and transcribing the data personally assisted the researcher in completing this phase.

**Memoing the Data.**

As data collection phases took place, the researcher made memos and comments electronically regarding the data being collected, organized, and transcribed. Memos are mostly a conversation to guide thinking post-interview and recall important thoughts (Clarke, 2005). Through data collection and analysis, the researcher developed memos in attempts to identify
connections and state reflections throughout the process (Lester et al., 2020). The memos assisted in guiding future questions, suggestions, or ideas that may assist the study in future data collection processes or investigations. Memos can be noted during interviews or directly on data as the transcribing process takes place.

**Coding the Data.**

Data was coded to identify themes and categories. Coding involves assigning labels or codes to specific words, phrases, or ideas in attempts to gain an understanding of the common concepts present in data sets (Yin, 2015). The researcher performed three rounds of coding, primarily searching for expected codes, surprising codes, and unique codes (Creswell, 2018). Each level of searching for codes is expected to present a new level of understanding and insight.

**Moving from Codes to Categories and Categories to Themes.**

Thematic analysis requires the researcher to move from codes to categories, to themes (Lester et al., 2020). Inductive coding was used to allow for the creation of codes based on the data itself, this is also called open coding (Vaughn & Turner, 2016). Understanding how codes relate to form categories and how categories interrelate to create themes is essential to finding data relationships. This process is not solely about finding similarities, but also recognizing the differences and relationships across all aspects of data (Lester et al., 2020). Themes are generally a representation of the goals of the study and should reflect the research questions and focus of the study (Lester et al., 2020). Utilizing hierarchical coding frames assisted in organizing and understanding how codes relate and themes emerge (Elliot, 2018).
**Coding Process.**

Qualitative data require the coding of the information provided by participants. Analyzing qualitative data is a long process needing careful guidance. The data analysis process consist of the five steps described by Creswell and Creswell (2018).

6) Organize and prepare the data for analysis: transcribing the interviews, conducting document review, typing up notes and memos, and arranging data to get organized.

7) Read or look at all the data: gain a general sense of the information and reflect on the meanings.

8) Start coding all the data: take the text and label it into categories.

9) Generate a description and themes: generate a description and categories or themes for analysis.

10) Representing the description and themes: describe how the themes were represented in the narrative.

Analyzing data is one of the most critical components of the qualitative research process (Leech & Onwuegbuzie, 2007). In qualitative studies, data analysis brings meaning to the study (Hatch, 2002). Through examining documents and conducting interviews, the researcher will sort and made notes on the collected data. While there is no sole correct way to analyze qualitative data, a rigorous analysis process presents impactful perspectives and themes (Raskind et al., 2019; Saldana & Omasta, 2018). Because qualitative research assists the researcher in understanding a phenomenon, data analysis helps bring meaning to the data set (Lester et al., 2020). Additionally, since qualitative data analysis is nonlinear, steps to analyze data do not take place in order; as such the investigator will use a phased protocol to uncover themes (Lester et al., 2020).
**Participant Recruitment**

The small school of study has limited options for participants. The school of study has three administrators that have a background in teaching and mathematics, they were asked to participate to contribute administrator perspectives. In addition, the entire mathematics department of five teachers were asked to participate in the study and contribute perspectives describing teaching processes and methods pertaining to rigor and college readiness. Each participant met the requirements to be in the study which was based on three criteria; currently teaching in a private school setting, status as a high school mathematics teacher or administrator, and at least three years of teaching or administration experience. All participants that were asked to be involved in the study agreed to participate and contribute perspectives through individual interviews or focus groups. Some participants expressed concerns prior to committing due to the ongoing pandemic, however, once it was stated that focus groups would be conducted over an online web conferencing software participation was confirmed.

**Participant Descriptions**

Administrator 1 (A1) is an administrator at the school of study who has been involved in education for 20 years. The 42-year old female has a Master’s degree in Educational Leadership which she utilizes in her current role as principal. Additionally, she also has a background in English, of which she still also teaches AP Literature at the school she is an administrator at. In her spare time, she teaches college courses in the high school as well as through a local university assisting in helping get college education students internships in high schools.

Administrator 2 (A2) is a 53-year-old male who has been involved in education for 25 years. He started his career out as a high school history teacher eventually furthering his education to obtaining a Master’s degree in Educational Leadership and working his way to
being a principal. He has worked in public and private school districts both as a teacher and administrative leader. While his children are all graduated and out of school he still enjoys working in the educational environment and assisting with preparing students for college.

Administrator 3 (A3) is a 61-year-old female who has previously worked in special education, specifically in study skill areas. After years of work in middle school and high school study skills classrooms assisting students in academics, went on to get her Master’s in Educational Leadership and has been a principal at the middle school and high school levels. Currently she is the lead administrator in the academic and counseling departments assisting students with academic pathways to college.

Teacher 1 (T1) is a 34-year old Caucasian male. The teacher who holds a bachelor’s degree in mathematics has always taught geometry and precalculus in his eight years of teaching. T1 also enjoys being part of clubs and activities through the school to be actively engaged with students and get to know them on a personal level. Additionally, his eight years of teaching has provided valuable growth on the process of getting students to understand and retain mathematical content.

Teacher 2 (T2) has been teaching for five years. She teaches freshmen and sophomores in Algebra 1 and Geometry, as well seniors in a college preparation math class. Her wide range of grade levels taught allows her to follow students through the years continually assisting them in mathematical skills and content comprehension. Her technology skills also allow her to incorporate technology into her classroom to create a diverse range of teaching strategies and methods for students to use as learning tools. Her classroom continually mixes up the methods and ways students are learning to encourage content knowledge.
Teacher 3 (T3) A native of the southeastern Minnesota area, T3 is a 29-year old Caucasian male who has been teaching for eight years. With a bachelor’s degree in mathematics he enjoys teaching the higher-level high school mathematics courses such as Calculus and AP Calculus. In addition, when needed, he will also teach Pre-Calculus and Algebra 2 if additional class sizes are needed. He enjoys being a coach for high school athletics to stay involved in the school community. As department chair, he oversees the mathematics curriculum, process, and teaching to continually assess the procedures to preparing students for college mathematic classes and careers in the future.

Teacher 4 (T4) is another native of the southeastern Minnesota area, T4 is a 29-year old mathematics teacher who has taught every mathematics class possible offered at high schools, from lower-level courses to higher-level courses. The range from Algebra 1 to Calculus, along with Statistics allows her to interact with all levels of students and have a broad mathematical mindset. In her past, she has also taught high school art, middle school science, and high school history. T4 is also known for having students come in before or after school for additional help to support content mastery.

Teacher 5 (T5) is the veteran of the teachers partaking in the focus group. T5 is a 43-year old female who has been teaching for 15 years, while mathematics is her specialty with teaching high school and college courses, she has also worked in special education. Currently she is teaching junior and senior mathematics courses such as Calculus, College Algebra, and Honors Pre-Calculus. She specializes in higher-level mathematics courses, as her background in teaching college mathematics courses assists her teaching methods as she attempts to prepare students for college years.
Table 3 contains demographic information pertaining to the high school of study. The table includes gender, race, age, years taught, classes taught, classes previously taught, and educational degree.

Table 4: Demographics of participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Race</th>
<th>Age</th>
<th>Years Taught</th>
<th>Classes Taught</th>
<th>Classes Previously Taught</th>
<th>Educational Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Administrator -Female</td>
<td>White</td>
<td>42</td>
<td>20</td>
<td>AP Literature</td>
<td>AP Literature</td>
<td>Master’s in Educational Leadership</td>
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<tr>
<td>A2</td>
<td>Administrator -Male</td>
<td>White</td>
<td>53</td>
<td>25</td>
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<td>History</td>
<td>Master’s in Educational Leadership</td>
</tr>
<tr>
<td>A3</td>
<td>Administrator -Female</td>
<td>White</td>
<td>61</td>
<td>35</td>
<td>Study Skills, Special Education</td>
<td>Study Skills</td>
<td>Master’s in Educational Leadership</td>
</tr>
<tr>
<td>T1</td>
<td>Male</td>
<td>White</td>
<td>34</td>
<td>8</td>
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<td>Pre-Calculus, Geometry</td>
<td>Bachelor’s in Mathematics</td>
</tr>
<tr>
<td>T2</td>
<td>Female</td>
<td>White</td>
<td>27</td>
<td>5</td>
<td>Geometry, College Math</td>
<td>College Math, Algebra 2, Geometry, Study Skills, Algebra 1</td>
<td>Master’s in Education</td>
</tr>
<tr>
<td>T3</td>
<td>Male</td>
<td>White</td>
<td>29</td>
<td>8</td>
<td>Calculus, AP Calculus, Pre-Calculus</td>
<td>Calculus, AP Calculus, Pre-Calculus, Algebra 2</td>
<td>Bachelor’s in Mathematics</td>
</tr>
<tr>
<td>T4</td>
<td>Female</td>
<td>White</td>
<td>29</td>
<td>5</td>
<td>Algebra 2, Pre-Calculus, Statistics</td>
<td>Geometry</td>
<td>Master’s in Education</td>
</tr>
<tr>
<td>T5</td>
<td>Female</td>
<td>White</td>
<td>43</td>
<td>15</td>
<td>Geometry, College Math, Calculus</td>
<td>Algebra I</td>
<td>Master’s in Education</td>
</tr>
</tbody>
</table>
Emergent Themes

Individual Interview and Focus Group Data

Four themes emerged from the analysis of data from the individual interview and focus group session. Textual quotes from the participants represent and support each theme. Quotes given are the statements provided during the interviews from the participants. Given under each theme are relevant quotes pertaining to the emergent theme. A summary of all emergent themes from the individual interviews and focus group session are provided in the below table.

Table 5:

Themes Derived from Online Individual and Focus Group Interviews

<table>
<thead>
<tr>
<th>Emergent Theme</th>
<th>Description</th>
<th>% of Participants Discussing Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Importance of Productive Struggle in Mathematic Instruction</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>Necessary Balance of Mathematical Conceptual Understanding with Skill Acquisition</td>
<td>75%</td>
</tr>
<tr>
<td>3</td>
<td>Connection of Continuous Assessment to Mathematic Content Mastery</td>
<td>87.5%</td>
</tr>
<tr>
<td>4</td>
<td>Variation and Customization of Mathematical Instructional Practices</td>
<td>100%</td>
</tr>
</tbody>
</table>
Emergent Theme 1: Importance of Productive Struggle in Mathematic Instruction

Teaching strategies that provide students with opportunities to struggle and challenge them to make sense of mathematics is a necessary component in the development in mathematical conceptual understanding (Zeybek, 2016). The first emerging theme revealed how teachers design lessons to encourage struggle and have students encounter difficulty as an effective way to guiding students to understanding. According to the data, all five mathematics teachers reported the inclusion of some form of instructional strategies to challenge the students and allow struggle to promote student learning. In addition, administrators also addressed the importance of challenging content and classroom instruction to encourage critical thinking and deeper thought processes.

The first theme emerged from interview questions 3 and 6, which asked how administrators and teachers encourage students to challenge themselves and push them to be successful. Interview question 3 asked participants the following: How do you motivate students to exceed expectations and continually challenge themselves?

The administration responses spoke about designing challenging curriculum and having discussions with students about challenges.

A1: Each class is designed to challenge students and keep requiring higher level thinking skills. I think the importance of teaching students to deal with these challenges presented is what sets them apart from public school students and classes. Each assignment should challenge them to a deeper level of thinking and learning, if the assignment doesn’t do that, it’s not helping the student.

A2: Often times we get students in the office that want to drop classes because the state they are too hard or challenging for them. We have to have careful
conversations regarding the challenge and struggle experienced and how that related to the effort provided by the student. We discuss that struggling is okay in a class, as it’s part of the learning process and that they are supposed to be challenged to promote growth. In our school, each class has its own type of challenges, and students need to understand that it doesn’t matter if they are in a regular, honors, or AP or college class—challenges will be present.

A3: We define challenge as problems that increase the process of thinking or challenge students in a way to promote growth. Giving a student a problem or question that challenges them is okay as long as it is possible for them to complete the problem using prior knowledge and understanding. If a student doesn’t think they have the proper knowledge to complete the problem they won’t even attempt it. From being in classrooms I love seeing teachers give challenging homework or class problems and then giving students small hints to get them started, you can even start to see it “click” for some students when that happens. It’s those moments that give the students confidence to keep trying.

In addition, teachers highlighted specifics about motivating students:

T1: I provide them with more challenging math problems to advance learning and make them think harder about what is asked. If they ask for help I don’t give them the correct answer right away, I allow them to think about it and work at it for a while by applying previous knowledge.

T2: I ask students questions during class and if they don’t know the answer I wait for them to talk through it and we will figure it out together. They might struggle
with talking in class and saying the answers out loud, but the students generally remember the process once they work through difficult problems on their own.

T3: On classroom assessments I assign problems that I didn’t exactly cover in class, they may be the next level of question in order to make them have to think harder and challenge them to apply previous knowledge. Even though this may be a struggle they actually work hard to understand and comprehend what is asked, most students want to complete the entire assignment.

T4: I use challenging activities in my classroom for all levels, in regular and honors, we do the same activities but just using appropriate problems. The extra challenge in math comes from challenging them to think differently or change the task that they have to do.

T5: I always have challenge problems that encourage students to work a little harder. Students like to solve problems and even though they struggle with the challenge problem they know I’m not going to give them the answer so they work harder to figure it out on their own. Some students even make it game to see who can figure it out first.

Interview question 6 asked participants: Do you believe it is important to push students to learn more and understand the presented information? If yes, why? If no, why? All participants agreed that pushing the students to be successful is an important aspect of education, and each response had a specific reason to support the answer. The responses are as follows:

A1: Students need to learn the content to reach mastery. If students are not pushed and helped through courses, they will not learn the material, often they skip over it and never come back to fully understand it.
A2: Absolutely. Teachers are here to support, guide, and influence the learning of students every step of the way and through everything the student may encounter.

A3: Yes. Some students are self-motivated, but many need the teacher to support, guide, and push them through. These are the same students that may shut down when they start to struggle so they need that extra motivation and push to keep going. Many times, if nobody is there to push a student that’s when we see grades start to fall to the point where it will be a struggle to get them back to passing.

T1: I do think it’s important that students reach the expectations of the material that needs to be learned in the class, especially since there is generally a step back over the summer break that happens each year it’s important to make them understand everything in the time we have with them even if it’s challenging for them.

T2: Yes, absolutely, here they have to learn each day to build off of knowledge. This is also supported by the assessments that are required here, if students are expecting frequent quizzes and checks they make sure they understand the information of the next day.

T3: Yes. Motivation is critical for students to understand and master content. Some students lack self-motivation and persistence and the nudge from me as a teacher is the driving force in some instances. There is no harm in learning more material ever, they learn to embrace the struggle presented.

T4: Yes, because they will need it in a later class, the struggle makes them use the higher levels of thinking in Blooms Taxonomy. The higher levels will help the succeed in whatever career they choose after high school.
As a follow up, teacher 4 was asked to expand on Bloom’s Taxonomy:

T4: I make my lessons basic at the beginning, students build confidence and really nail down the basic skills needed, we don’t move on to harder content until we understand the basics, if we do that, than I know many kids will get lost as the lesson progresses. Once the basic skills are done, I can open up the classroom and expect more out of the students and put more on them. I give harder problems, longer problems, or have them do them on the board. It’s really fun to see how students struggle at the board and start to get nervous when they don’t understand it, but once they talk through they start to remember the basics and help themselves out. The class also hates to see their classmates struggle, so if there is an issue, someone usually starts calling out help or hints. When this happens, I can see what students are moving up the scale, because you have to understand something completely yourself before you start helping others.

Continuing on participant 5 responded to the original question stating:

T5: Yes. Many students do not push themselves, so it’s up to us as teachers to do that and keep them going. They need to know that we are there to challenge them, help them through the difficult times, and push them to reaching their goals. Every step of the way, we are there to make sure they do not go backwards.

All three administrators clearly felt that pushing students through the rigor of the course and promoting challenge through various instructional practices is highly beneficial which ties back to the literature review where Morgan et. al. (2018) stated that classrooms with increased academic intensity and challenges prepares students for skills needed after graduation. A3’s point was critical in emphasizing the growth students encounter throughout the mathematical
process supporting Wojcick’s (2017) discussion on the importance of using multiple strategies to develop conceptual understanding and strengthen procedural fluency. In addition, all five teachers addressed how they challenge and motivate students in a way to support learning, according to Saphier (2016), a teacher who holds students to high expectations sets the tone of the class creating an atmosphere where students are able to believe in themselves and reach success. All administrators and teachers suggested that productive struggle is highly beneficial in students’ educational experiences. Challenging and pushing students to success is a way to prepare them for futures in college and careers (Boser & Rosenthal, 2019).

**Emergent Theme 2: Necessary Balance of Mathematical Conceptual Understanding with Skill Acquisition**

Understanding a mathematical concept does not solely mean memorizing a definition of the topic (Rakhim, Kartono, & Supriyadi, 2021). Each mathematical concept requires skills and an understanding that relates each element back to precious knowledge and links relationships with precious skills and methods learned (Rakhim, Kartono, & Supriyadi, 2021). Theme two discusses the relationship between balancing conceptual understanding with skill acquisition. Specifically, teachers speak to the importance of building student understanding through making sure they understand not only the concepts, but the proper process and skills.

The second emerging theme was derived from interview responses in interview questions 2, 12, and 13. All five teachers interviewed discussed the importance of the process in mathematics that leads to mastery, one administrator also weighed in on the discussion.

Interview question 2 asked: How do you employ mathematical instructional strategies in the classroom? Several participants discussed their own strategies and the effects they have on student understanding and skill acquisition.
T1: I use the “gradual release of responsibility” to assure that the students are gaining an understanding of each type of problem required. I teach the basics over one or two problems, then I have them discuss and talk through the steps with me. As we keep going the problems get harder but they start understanding the concepts and content from the beginning and start getting held up on the harder steps. Basically, the skills constantly build as we go through the lesson, growing from easier to harder.

T2: I have small turn and talks during the class. This allows students to discuss with a neighbor the steps we are doing and talk through the problem out loud. Keeping them engaged and thinking for the duration of the class period helps them remember what we did at the beginning. I do a lot of demonstration, and then have them mimic what I did.

T3: I use the cycle of learning in my class, we build on problems to understand the steps and get the basic concepts, but then we go back and keep going through them and they get harder each time. If we get stuck on a problem then we go back and do an easier one again or discuss where the issue was.

Interview question 12 questioned: Would you like to share any additional feedback about how you prepare students for college-level mathematics courses?

A2: As an administrator we encourage teachers to use the multiple assessments and examples as a way to keep students reviewing and getting ready for success during the units. We want students to feel comfortable with the frequent tests so they do not blank on the skills when asked to perform them.
T3: I challenge my students as much as possible on concepts during the lesson, I want them to see every type and situation that may occur so they can ask questions prior to beginning homework. We do problems until I am getting a thumbs up from students or until they are begging me to stop and screaming that they understand it.

T5: I continually review and revisit topics. The skills needed to be successful in mathematics class in high school and college are basic level Algebra skills, but students need to keep seeing them to remember and master them. Just because I finish a chapter and test on a it, does not mean that I will never give those same types of questions to students again.

Interview question 13 asked: What foundational concepts do you as a mathematics teacher use to assess high school students’ college mathematic readiness?

T1: I generally look at students work to assess their level of understanding not solely based on their answer but based on how they arrived there. I also look for mathematical understanding and knowledge shown even in incorrect answers to see what they possibly did wrong. This helps me figure out if they are having a hard time with the concept or the skills, sometimes a student does not even know what a problem is asking and can’t even begin a problem, and sometimes, they get stuck halfway through.

T4: I use rigor in my curriculum to make sure students are understanding what they need to not only be successful in high school but carry that knowledge with them to college. My students know they will be asked to complete content and understand concepts in a variety of ways. Students can often one type of problem
successfully, but if you write it as a word problem or ask them to complete it backwards than they struggle. I do not believe students master the skills required until they can apply them to a variety of scenarios.

Addressing understanding and skill mastery T1 and T3 addressed the importance of carefully structuring classes to consist of problems and homework through increasing difficulty as the class goes on to promote and encourage growth. In support of Rosario et al.’s (2015) three common purposes of homework; practice, prepare, and extend, these two teachers have students practice problems in class together, prepare them with the steps needed to be successful, and then increase the difficulty to have students extend their thinking and grow in the conceptual understanding and skill areas. Through encouraging students to work with peers, think critically and combine multiple past topics, students are able to apply knowledge to be successful (Rosario et al., 2015).

T5 and T4 provided perspectives regarding how their specific classes continually revisit topics and content in hopes that student will retain and remember the skills needed for the mathematical process. A well-rounded curriculum has the ability to benefit every type of learner in the classroom (Suprayogi et al., 2017). Specifically, these teachers utilize strategies that assist students with conceptual understanding and skill acquisition, the teacher facilitates and assists students to knowledge and mastery (Matthews, 2020). The research supports that students need to develop the skills leading to higher-level thinking and understanding through being engaged and participating in a complex learning environment (Edumds et al., 2017) just as these teachers describe and implement in the specific classrooms.
Emergent Theme 3: Connection of Continuous Assessment to Mathematical Content

Mastery

The primary purpose of assessments is to improve student learning and provide feedback to students on performance (Tanujaya, 2017). Assessments aim to gather data that reflect the level a student is performing and how well the student is achieving on the content required in the course (Tanujaya, 2017). In addition, students often report that feedback is provided too late during courses to have a positive effect on performance (Tanuyaya, 2017). Continuous assessments are emphasized and an important factor of student learning and content mastery in this private school of study to hold students accountable and provide continuous feedback to support learning.

The third emerging theme derived from responses to interview questions 5, 9, and 11. The three questions asked about high school curriculum and instructional approaches to support preparation and readiness for college courses. Through these questions teacher and administrators spoke to the importance of assessments in student content mastery leading to preparation and knowledge for college. Through these questions, each participant emphasized the importance of the implemented frequent assessments in the private school of study and the effects it has on student content mastery.

Interview question 5 asked: Do you feel like graduating students are prepared for college mathematics courses?

A1: I actually do not know the specific numbers, it would be something we should add to our data collection for end of the year and graduating seniors, but I do know our students generally do not have to be placed in remedial mathematics coursework once they leave us and go to college, so I would say yes. Our
students score well in math, we are doing a good job at making sure our students meet math benchmarks. Part of it is the assessment requirement applies to honors and advanced level classes as well as our regular classes. We assess our lower level students the same in hopes to help them with content retention.

T1: Yes, I believe if they go through a rigorous course they are prepared, however, students get out of it what they put into it. We give many summative and formative assessments to constantly be assessing students, not just for grading purposes but to see where students are more frequently in understanding the material. Many of the students do study hard, and take the assessments seriously.

At this school we really try to mimic college courses so they will be used to the environment they will encounter at college such as course grades being heavily weighted on assessments.

Interview question 9 asked: What are some of the indicators that you use to determine if a student is progressing towards college and career readiness in mathematics?

T4: The multiple types of assessments definitely help, as it gives both of us a good understanding of where they’re at and how they’re doing. It helps know if they are retaining knowledge. So much of math is remembering and understanding the procedure, all of that content is going to come up again in their future, they can’t just remember it for a test and then forget it and put it behind them. They need to remember it. We make sure we are constantly focusing on what is needed for college and what standards should be learned, they need to master that content prior to moving on to college. One of the effective ways to do
this is assess the kids often so they have feedback throughout the units, not just at the end.

T5: If students are meeting benchmarks, I feel confident they are prepared for the next level of content. In my courses students really like how many mini-quizzes I give, which are small assessments throughout the week that assesses if they understand that day’s material or the previous days. If several students do not do well, I reteach the lesson until there is clarity. From the students they say they like them, because it helps them stay current on the homework and lessons, they know we might have these small assessments so they work hard to understand the work each day rather than put it off until the end of the unit test.

Last, interview question 11 asked: Can you explain how the high school mathematics curriculum prepares high school students for college-level coursework?

A1: We make sure our students are getting plenty of work and examples to prepare them for college. A lot of college is lecture, watching the professor do the skills, and then students are asked to go do it on their own. Most of the learning has to come from seeing what the instructor is doing, students don’t know what they don’t know, they need to be guided through examples and see what the result should be before they are expected to do it. The tests we take also prepare them for what to expect in college.

A2: All of our curriculum and expectations at this school were created at a high level. We are a college-preparatory campus so our goal is to prepare them for post-graduation college courses and paths. We require our teachers to have a set number of assessments by mid-quarter, and quarter in order to promote continual
assessments. Often times we hear students putting off studying until the day or two prior to an assessment. Here, since they know we have frequent assessments they study and learn the material throughout the units, successfully understanding the content before the end of the unit. For the most part, our students are succeeding and learning the material, and that’s supported by our higher testing scores.

To further the conversation, the researcher asked A2, one of the administrators, the follow-up question: You stated the school scores higher on testing, which tests are those and do you think the assessments are a direct influence on those?

A2: Specifically, our ACT and AP scores are higher than the state averages, and I do believe the assessment requirements are a direct influence. Students develop a study technique which is reviewing material and working to understand it continually, they study through the units, not just at the end. Our frequent assessments force our students to hold themselves accountable and be prepared.

A3: It comes down to our high standards, the assessments, the rigor, the curriculum, the push to be academically ready. We talk about college a lot, more than they do in other schools, so students know the requirements and start hearing about it early. Many schools wait until students are juniors to have the college discussion, right away with our freshmen we talk about what their GPA their first year of high school will do to them if it does not go well. We tell the students the challenge is not just to push them in high school, but it will benefit them in college, so they understand the purpose behind the academic requirements here.
T2: We have a rigorous curriculum and high assessment expectations. We use assessments to support student learning and guide them to understanding, not just learning for a test. Since we are constantly assessing students, they have to learn it, and then keep learning it and working at it. Much of college is assessments, so we mimic that here to prepare them for what they will get in college.

T4: Our curriculum is challenging and challenges the students to work hard, we test and quiz them like crazy so they are generally prepared for that. When I first heard about all the assessments we had to give I was nervous, as I thought it would stress out the students and I would deal with more academic struggles, it has helped the students prepare for final unit tests or final exams, like what they will see in college. They learn to prepare and learn every day’s stuff, and not just put it off.

A2 highlighted an important aspect regarding the school of study. According to Frenette & Chan (2015), private high school mathematics and test scores are significantly higher than those of private schools. A2 addressed this specifically stating that the schools test scores stand above the state and national averages, this was related to the fact that the administration pushes teachers to prepare classrooms and instructional strategies for students to be academically successful. In most circumstances, students who attend private schools outperform those who attend public schools (Sakellariou, 2017).

In addition, A3 and T2 offered perspectives regarding the benefit the testing and rigor for preparing students for college. Preparing for the academic demands of college is a main component of college success (Kurlaender et al., 2019). Both noted that providing students with an understanding of the structure of college assists in giving students an insight to the years after
high school. The role of high schools is to prepare students for post-secondary options and to be successful with any faced challenges after high school graduation (Snir et al., 2017).

T1, T3, T4, and T5 discussed how beneficial the testing requirements and rigor are at the school. Through assisting students with content retention, skill mastery, and continual feedback, the teachers were in favor of the multiple assessment requirements. Furthermore, getting students to practice test taking strategies also provides educational benefits. Higher test scores allow admittance to a wider range of postsecondary institutions (Moore & San Pedro, 2019). When implementation of rigor is done correctly, the teacher is doing his or her best to prepare students for academic success in post-graduate years (McNulty & Quaglia, 2007).

Emergent Theme 4: Variation and Customization of Mathematical Instructional Practices

Around the world, many schools are adapting more in-depth rigorous academics with the hopes of increasing the educational productivity in the classroom (Shirrell, Hopkins, & Spillane, 2019). This change has forced teachers to utilize a variety of instructional strategies and pay close attention to the way content is presented to students (Shirrell, Hopkins, & Spillane, 2019). Using differentiated instructional practices helps respond to the various needs students have, providing them with a more efficient learning environment (Pozas, Letzel, & Schneider, 2020).

Theme four derived from questions 7, 8, 14, and 15, which focused on the various instructional strategies that teacher uses in the classroom at the school of study. Data showed that each teacher has a different way of conducting and teaching the material in content, as well as a various way to assess if those strategies are working. All five teachers discussed the diverse instructional strategies used in their classrooms, and each administrator responded regarding instructional strategies that are encouraged to be used across the school.
Interview question number 7 asked: What approaches do you take to differentiate instruction to accommodate varying comprehension levels and understanding when planning a lesson?

A1: At this school we require teachers to have a set number of assessments in a quarter. This plays a role in comprehension and understanding because some students need those small knowledge checks along the way to keep them on task. Those students that don’t need them as much just end up doing fine on them and getting extra points in the assessment categories. We also know it helps those students who do not test well on end of unit, larger tests. They get the opportunity to show what they know throughout the chapter and not just at the end.

T1: I feel that there is some differentiation that is to be done in part of students registering for correct classes (and that itself can be a tough task to do/figure out). As for differing levels of comprehension in the same class, I generally have questions at the beginning of the lesson (or regarding a specific topic/theorem) that are of a more basic understanding and after a few basic questions, I will offer a challenge question on the same topic. This gives the higher understanding students a chance for a challenge as well. I also find assigning homework can be done in a way that either challenges students or checks for basic understanding. It is rare for me to assign a special set for higher comprehension students - I try to aim for around 80-85% of the homework at the standard level of understanding and 15-20% of the questions (or time of homework) on more challenging questions. In lower level classes, I generally have a lot more questions on basic understanding as it may take some students 2 or 3 examples to understand while
others may need 4 to 6 examples. I try to let students try on their own after 2 examples so I can assess where the students are at and give more instruction/feedback/examples if most students need more. I can also use work time (limited to lower level classes) to help instruct those who needed more examples [to avoid losing those at the higher level].

T2: I make sure I scaffold my lesson; I start with basic questions and through the lesson steps get added and get harder. They see the very basic examples and steps and then we add one by one. I find it that students mentally check out as soon as they are presented with a really long problem, so we need to build through the lesson. This also helps address where students get lost or confused, as they are able to pinpoint which "step" is a struggle and gave complications.

T3: I am big on group work. I intentionally pair strong and weak students together so they can learn from one another. Small groups are less intimidating enabling students to be more inclined to interact and describe areas of weakness. I also begin each class with a review session. I make sure all students are on the same page before we advance to a new concept. Planning a lesson and incorporating activities to reach all learning styles and levels is main priority.

T4: I try to think of at least two different ways to explain the concept before teaching it. We also have different levels (i.e.: honors) at this school to help differentiate as well. I will also highlight the most important concepts to tell the students as well.

Interview question number 8 asked: Can you explain activities or teaching tricks that you employ to get more out of students?
A2: Teachers are encouraged to engage with each student every day. When we observe our teachers, we want to see those interactions instead of teachers just dictating the classroom each lesson and students just sitting there receiving the information. Research shows that if students are engaged they are able to learn and take in the information more efficiently, if students know they may be called on, asked questions, or asked to do problems on the board, they stay engaged, as students don’t like to be wrong or have no idea what to answer when asked.

A3: I encourage teachers to constantly be asking questions and assessing students. This is a requirement of this school, but it is also one of the keys to getting students to understand the content. When you assess students more often it allows the teachers to see where gaps are so the material can be retaught. If students know they will be assessed they will also work harder to understand it more. I notice the students here are more academically motivated compared to public schools so the thought of having multiple assessments honestly motivates them enough. We have really good kids here who want to do well.

T1: I use notes booklets for each chapter, kind of like guided notes that help them start the thinking, I think they help as they use less time to write down the problem and can start focusing on learning and processing the content right away. So often students are struggling to get math problems down and by that point the teacher has already explained it. I also think it helps them stay organized and study, students often remember “where in the booklet” content was and remember what page it was on or how the problems started. I also have solid study guides that help students prepare for assessments.
T2: I focus on building relationships with them, I am not sure if it’s an instructional strategy, but getting to know students and building a relationship with them helps them know you care about them and their success.

T3: Games and interactive assignments, when the day includes a competitive component, students are more engaged and likely to be assertive demonstrating knowledge. Sometimes I award extra credit points for students going above and beyond. This approach motivates students to learn more and be actively engaged.

T4: Cold calls, individual work time, partner work time, exit tickets, open questions to anybody that has an answer, review days, review assignments, voting as a class on an answer, asking challenge questions and have them work to figure them out.

T5: I change it up every day trying to keep it interesting for students, they never really know what the lesson is going to include, so I think when they come in they are engaged right away trying to figure out what we are doing.

Interview question number 14 asked: How do you implement rigor in the classroom?

A1: We encourage rigor in this school as a key instructional strategy, our teachers take PD (professional development) on how to use rigor and how to use it efficiently. Some teachers think that rigor is just increasing difficulty, however, it really comes down to the teaching strategies, methods, and classroom process instead of just difficulty.

A2: One of our school goals is to have rigorous curriculum so we make sure we are talking with our teachers about what they are doing in the classroom and if it is working or not. For the most part, I see the teachers using a wide range of
strategies to support student learning. When I go into classrooms I always see something different happening or a different activity, most of our classrooms have their own “style” and that’s really fun to see, the students aren’t just doing the same thing all day, they are being forced to learn, be engaged, and understand in a variety of different ways.

T1: Rigor in the classroom is being strategically prepared. As the initial lesson is taught, we are focusing on the basic concepts. However, reinforcing the content is where I integrate rigor. It challenges students to apply the prior knowledge and build upon it to strengthen the concepts. Rigor is evidenced by assignments devised focusing on higher level thinking with the concepts and raised expectations on participation. I expect all students to remain actively engaged in the learning opportunities and promote supplemental activities to reinforce learning.

T2: I feel that I implement rigor in challenging homework questions, some challenging questions during the lessons as well as having a generally aggressive schedule in achieving all the end goals for a class whether the number of school days is cut due to the pandemic or by snow days. I always try to prepare them as well as possible for their next course in math.

T3: Through various assessments and scaffolding of lesson plans, having finals, making homework worth small points, asking students to interact, do problems on the board, answer questions, mini-checks, continually assessing, increasing problem difficulty, asking them why or how to increase thinking.
T5: No retakes, homework is worth very little towards their grade, exit tickets to make sure they are asking questions during class so they understand before they leave, and a final at the end of each semester.

Interview question number 15 asked: How do you describe the mathematical instructional strategies used to prepare secondary students for college mathematics courses?

A1: In our math classrooms we are constantly talking about assessments and preparing them for what test questions might ask. We don’t necessarily teach to the test, but we do make sure we prepare them for what they will see. Testing is a huge part of college, so we make sure that our students know testing strategies and can handle that pressure.

A2: We make sure we are always talking about the mathematical paths through high school as well as college. For the students, when they want to know why they need to know something, we explain it. Specifically, we make sure students know that the path they take through high school math classes will make a difference in college for them. Students who make it through calc in high school will be more set for succeeding in college mathematics. As well as the instructional strategies they see through these classes will prepare them as well.

T1: I think the instructional strategies for preparing math students for college comes in the form of how lessons are taught at a higher, and sometimes less interactive level than middle school. I feel that a lot of my college level classes were mostly lectures and not as many questions and answers compared to middle school. A lot of my classes for 9th/10th graders start with more questions and answers and as I move on to 11th/12th grade, it can become a little more lecture
based as the amount of material to cover in Honors Pre-Calculus is much more than what is covered in Honors Geometry. I also feel the emphasis on self-discipline of coming in on your own time when students have questions, if there wasn't enough time to answer in class, is important as those situations often happen in college- where you need to know your professors office hours in order to have questions answered.

T2: They are harder and have higher expectations, they continually assess students and ask them to recall and remember knowledge, students are expected to develop knowledge and hold themselves accountable, they need to recognize when they are struggling and come in for help. As teachers we can tell them they are struggling, but much like at college we aren't going to chase them down, they need to hold themselves accountable.

T3: I let students know they need to ask questions when they do not understand something; take responsibility for their work; have students answer questions during class time. I also have them use previous knowledge to learn new concepts by asking them questions rather than them asking me, they are forced to recall information; no retakes; have off days for students to ask questions, similar to office hours in college; when homework is completed late, they receive less possible points.

T4: As teachers we make sure we are talking about college math content and making the problems harder as we go. We hold our students to high standards, they do not just get by, they are expected to excel and understand content, I think for the most part the students want to do well.
Four teachers offered different perspectives on strategic planning to vary and customize instructional practices. T1 addressed the importance of planning lessons to address all levels of comprehension through using notes booklets, T2 discussed scaffolding lessons to promote growth, T3 talked about various classroom activities to promote engagement student participation, T4 discussed multiple ways to teach the same lesson in hopes that various methods would appeal to various students. All of these strategies are supported through Blackburns (2018) strategies of creating a classroom that has the ability to address all students needs and promote student growth. Including rigor in the classroom means setting up the classroom with well-rounded curriculum (James, 2016) and paying careful attention to how teachers present information and set up classrooms (Blackburn, 2020), just as these teachers have reported doing.

**Summary of Interviews**

The data collection process consisted of individual interviews and a focus group conducted through an online web conferencing platform due to the ongoing Coronavirus pandemic which requires social distancing. The researcher developed questions for online interviews that aligned with the research questions that guided the study. Close-ended questions obtained demographic data from the participants, and open-ended questions were asked regarding the experiences of the administrators and mathematic teachers’ years in education. Specifically, the questions addressed the instructional strategies used and desired by the administrators and teachers, how rigor is implemented, and the concepts needed for administrators and teachers to address college readiness of high school students. The participants answered the questions willingly and appropriately, leaving room for discussions to take place. However, discussions were minimal, as teachers are stressed and have many tasks to attend to due to teaching online and in-person at the school of study. Nonetheless, all
administrators and teachers interviewed provided feedback based on experiences, observations and perceptions while working in the private school of study.

**Document Review Findings**

To understand the drive behind processes in the private school of study as well as the state educational system regarding mathematics, the investigator analyzed documents from the school as well as the state. Documents included, the most recent strategic plan from the school, the faculty handbook, classroom documents such as lesson plans and syllabi, and the states most recent career and college readiness guide.

**Minnesota Career and College Readiness Resource Guide**

The Minnesota Career and College Readiness Resource Guide aims to organize the indicators that measure career and college readiness as a resource for schools to improve outcomes for students and close achievement gaps. The guide attempts to assist schools on the path to compiling and evaluating their own school data to support accountability, academic progress, and student success (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). The two main focuses of the document is to assure that one-hundred percent of students are college and career ready, and that statewide, the graduation rate is ninety percent. Five categories make up the document, social-emotional learning, college and career readiness, academic performance, additional relevant data, and continuous improvement. Pertaining to this study, career readiness, academic performance, and continuous improvement are three components most relatable.

College and career readiness focus on curriculum and instructional strategies that allow all levels of students, especially those in high school to explore a variety of college and career options. The goal in the document states that all students should have equitable access to
relevant knowledge and skill across a variety of career possibilities (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Allowing students to connect and engage with people in their field of interest supports the decisions to start pursuing college and career pathways (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Preparing students for college and careers includes helping explore classes and pathways and educating them about rigorous courses to take in high school to promote readiness (Minnesota College Readiness Resource Guide: Data Inquiry, 2018).

Academic performance includes the summative and formative assessments as a reflection of the work students have put into learning the knowledge, skills, and abilities to transition to college and career choices. The academic performance starts in kindergarten and grows through high school but paying careful attention to attendance, disciplinary actions, reading and mathematics achievement, high school performance, and graduation rates (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). The students are followed through all their school years, not just focused on in the four years of high school. In mathematics specifically, the goal is to have 90 percent of all students scoring proficient or higher by eighth grade, with no student subgroup below eighty-five percent by 2025 (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). In addition, ninety percent of all Minnesota students should be proficient in mathematics by 2025 (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Regarding rigorous courses, the document supports the encouragement to take AP and college-level courses while enrolled in high school to prepare for the rigor in college (Minnesota College Readiness Resource Guide: Data Inquiry, 2018).

Continuous improvement supports the ongoing process of monitoring activities, curriculum, program evaluations, formative and summative data, support services, and teacher
professional development. With the idea to continually be striving to support and assist students to achieving their highest level of academic ability and move them closer to career and college goals, continuous improvement is always seeking to better the educational system (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Continuous improvement includes new curriculum, teaching strategies, or assisting in creating school strategic plans.

All the document’s goals, plans, and ideas support the idea to get 90 percent of all students to graduate after four years of high school (Minnesota College Readiness Resource Guide: Data Inquiry, 2018). Each student deserves the opportunity to succeed and be given the chance to go on to college prepared with the needed skills. Through providing guided steps to implementation in schools and the suggestions, the document aims to assist each school in reaching the desired statewide goals (Minnesota College Readiness Resource Guide: Data Inquiry, 2018).

**School District Strategic Plan 2016-2020**

The school of study’s strategic plan is a summary of the steps to achieve an environment that develops the spiritual, social, emotional, and academic growth of students in the facility. The strategic plan encompasses the goals and objectives of the school emphasizing the importance of the catholic identity, academics, financial performance, as well as stakeholder engagement. Academics and student success is the highlight of the document as several objectives included the support and measures that need to be taken and maintained to continue the college preparatory environment which prepares students to graduate and be ready for college courses. Objectives three through five are focused on the academic aspect of the school.

Objective three states that the school of study will embrace a personalized approach to learning to meet the needs of all learners (School of Study Strategic Plan, 2016, p.1). Objective
four goes on to state that the school will have all students prepared for college, and objective five goes on to require the staff members to implement creative programming, challenging course options, and authentic field experience to support student success in a dynamic 21st century world (School of Study Strategic Plan, 2016, p.1).

Overall, two major points are made in the document to support the objectives, the first is that the school will pursue excellence for students of all academic abilities, and the second is the school will retain and attract the highest quality faculty and staff to support academic success (School of Study Strategic Plan, 2016, p.7). To support the first point in pursuing academic excellence, the document supports the importance of having and maintaining a rigorous curriculum that aligns with relevant standards and skills that can be applied to the diverse range of students in the school. Assuring that each classroom has rigorous curriculum presented through effective instruction is mandatory as it intends to provide the students with the 21st century skillset to be successful post-graduation (School of Study Strategic Plan, 2016, p.7). To accomplish this goal, an emphasis is placed on recognizing assessment methods that document student achievement, reviewing and assessing curriculum and instructional practices, and focusing on ways to pursue continuous improvement through rigor (School of Study Strategic Plan, 2016, p.7). In addition, the goal is to focus on supporting the lower level students, as well as the higher students through the creation of support services for struggling students, as well as enrichment programs for the gifted students such as higher-level courses (School of Study Strategic Plan, p.7).

Second, the document supports the importance of high-quality faculty and staff to assist students in meeting the academic goals of the school. The importance comes from the school desire to recognize that faculty and staff play a critical role in creating an environment of
academic excellence (School of Study Strategic Plan, 2016, p.7). Specifically, the school strives to “recruit, train, nurture, and retain faculty and staff who meet and exceed diocesan requirements for academic and religious formation, and demonstrate continuous and improved knowledge and skills necessary for effective instruction” (School of Study Strategic Plan, 2016, p.7). To reach and maintain this goal, the document discusses the measures to be successful in this area requiring how to support faculty retention. Developing a highly competitive salary and compensation package, developing and partnering with higher education teacher leadership preparation programs to create a pipeline for future employment, and promoting a culture that supports the professional spiritual and personal growth of its employees are on the agenda to reaching retention success (School of Study Strategic Plan, 2016, p.7). With the highly qualified faculty, the school administration will assist in analyzing and evaluating data to improve the quality and effectiveness of teaching and learning outcomes (School of Study Strategic Plan, 2016, p.8). Through educating teachers and staff on implementing a creative curriculum, the desire is to prepare staff to teach college and university equivalent courses. Ideally, the school is constantly seeking growth and completing action steps to academically prepare students for college education.

**Faculty Handbook**

The faculty handbook highlights the academic requirements placed on the teachers and staff who work in the school of study. The academic requirements support the school’s goal of enhancing student achievement, improving student engagement, and incorporating fundamental changes in teaching strategies, curriculum delivery, and classroom management. Through requiring teachers to use a rigorous curriculum, the school believes the academic preparedness and college readiness of graduating seniors is high (Faculty Handbook, 2018).
The document clearly states that individual teachers may establish specific expectations for individual classes, however, there are necessary requirements in those classroom expectations that must take place in the classroom (Faculty Handbook, 2018, p.7). One requirement is that the teacher must update the gradebook every ten days to continually give students grade feedback throughout the school year (Faculty Handbook, 2018, p.8). The rationale for this requirement is the desire to encourage students to become self-disciplined and take responsibility for their grades. Allowing students to continually see their progress and how performance effects grades encourages academic awareness.

Second, by mid-quarter, teachers must have at least one summative assessment and eight to ten formal formative assessments (Faculty Handbook, 2018, p. 9). Summative assessments may include, but are not limited to end-of-unit or end-of-chapter tests, projects, portfolios, or performance assessments (Faculty Handbook, 2018, p. 9). Formal formative assessments may include quizzes, diagrams, concept maps, posters, tweets, Instagram posts, class discussions, flip-grids, jigsaw groups and presentations (Faculty Handbook, 2018, p. 9). Thus, by end of the quarter, each teacher needs to have at least three summative assessments and sixteen to twenty formal formative assessments. It is also required that all assessments should receive written feedback from the teacher to provide feedback to students.

Last, is the requirement for a blend in instructional strategies and have a diverse curriculum across the mathematics class. Examples included in the document are a blend of traditional lectures, discussions, internships, capstones, and group activities (Faculty Handbook, 2018, p. 10). The goal is to design curriculum that prepares graduates for college and the increasing demands of our modern world (Faculty Handbook, 2018, p. 11). The rigorous coursework options and required diverse teaching strategies keep the students thinking critically
and address the needs of the various levels of students to promote academic growth (Faculty Handbook, 2018, p. 12).

**Classroom Documents**

Examining classroom documents such as syllabi and lesson plans provides an insight into the classrooms and curriculum at the school of study. While each classroom has individualized processes, curriculum, and instructional strategies, the overall requirements and methods used in the mathematics department was similar across each teacher’s classroom. The course objectives, grading processes, and requirements all reflect one another.

Specifically, the grading scale was the largest commonality with all five teachers choosing to have homework as the lowest grade-influencing category, weighted to reflect only five percent of the student’s grade, with the resulting 95 percent being composed of assessments including quizzes and tests. In addition, each classroom has a no-retake policy for any assessment, students are encouraged to ask questions on problems that were incorrect to still learn from them, however, the corrections would not increase the final grade of the assessment.

Another commonality was the course objectives which stated the goal of the course was to not only learn the classroom content, but to prepare students for the next level of mathematics course to be taken, for the lower grade-level students, that is for the next mathematics course in the sequence, for seniors, the goal is to prepare them for college-level mathematics. Each document specifically spoke to preparation for the future.

Last, the documents carefully reflected the requirements for the course, late work would not be accepted, any mid-quarter or end of the quarter grades that were below 70 percent would result in an academic plan being enforced along with progress reports sent out to parents.
Academic requirements are strictly enforced and communicated to students and parents through these documents.

Classroom lesson plans were also carefully reviewed, and in support of the interviews that took place with the classroom teachers, the plans are structured to promote growth, student’s success, and content retention. Many components written in the lesson plans allowed specific times for knowledge checks, exit tickets, and assessments throughout the units and lessons to check for student knowledge and understanding. Each teacher had a specific teaching strategy, notes booklets, lecture, handouts, games, worksheets, and projects, but among all the diverse plans, assessment and understanding was maintained through all of it.

**Summary of Documents**

Each document reviewed addressed rigorous curriculum and classes, student success, and college readiness. Overall, the goals and future plans of the classrooms, school, and state align to provide students with the best education possible and prepare them for the paths they may take in the years after high school graduation. Offering support, guidance, and pathways to achieving the desired goals, each document distinctly outlines the process and steps to a better school environment, education, and experience for students.

**Summary**

The participation of the three administrators and five mathematics teachers with the use of multiple data collection methods ensured triangulation and provided themes to add to the validity of the study. Four themes emerged from the one-on-one interviews and focus group: (a) Importance of Productive Struggle in Mathematic Instruction; (b) Necessary Balance of Conceptual Understanding with Skill Acquisition; (c) Connection of Continuous Assessment Content Mastery and (d) Variation and Customization of Instructional Practices. Chapter V
comprises a discussion of the conclusions, implications for higher education, and recommendations for future research.
Chapter 5

DISCUSSION, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

This qualitative study explored the experiences and perspectives of private high school administrators and teachers on best mathematical instructional strategies and the role rigor plays in improving college readiness. Chapter I introduced the foundational overview and purpose of the study. Chapter II provided a review of the literature regarding private school rigor, instructional strategies, and mathematic college readiness. Chapter III described the rationale for choosing a qualitative phenomenological design. Chapter IV presented findings derived from online individual interviews, focus groups, and document review. Chapter V examines the findings, and conclusions related to each of the research questions, discusses implications, and offers recommendations for practice and further research.

Discussion

This phenomenological investigation on the perceptions of private high school administrators and mathematics teachers on instructional strategies and rigor for improving college readiness has shown valuable results. This investigation contributed information that could contribute to the body of knowledge on preparing students for college mathematics classes. Four themes emerged from the study: (a) Importance of Productive Struggle in Mathematic Instruction; (b) Necessary Balance of Mathematical Conceptual Understanding with Skill Acquisition; (c) Connection of Continuous Assessment to Mathematic Content Mastery and (d) Variation and Customization of Mathematical Instructional Practices.

The setting for this study was a private high school with a ranking of one of the top 25 private schools in the state with its graduation rate of 100%. The school is in a large
southeastern Minnesota, metropolitan area with a population of 220,000 people, and home to a major hospital. At the small school district, three administrators who have been in education for over twenty years and five mathematics teachers who have been teaching for five or more years, chose to participate in the study. Five of the participants, three teachers and two administrators, are female, and remaining two teachers and one administrator are male. Participants shared rigorous classroom instructional strategies to support and prepare students for college mathematic readiness.

The individual responses were critical components in framing the four emergent themes of the investigation. Participants gave detailed responses to the interview questions during the individual and focus group interviews. Additionally, a review of the district’s most recent strategic plan, faculty handbook, classroom documents, and Minnesota’s Career and College Readiness Resource Guide highlighted important priorities for the school and state’s future in preparing students for college mathematics courses. The three forms of data collection helped the researcher triangulate data to assure credible and reliable data (Creswell & Creswell, 2018).

**Theoretical Connections**

Bruner’s Spiral Curriculum Theory advocates for the scaffolding of curriculum by a continual cycle of revisiting topics, with each time increasing the rigor and difficulty to strengthen and deepen the understanding of the content (Cowan et al., 1998). Bruner (1962) states that a spiral curriculum “turns back on itself at higher levels” and can be taught to any student at any developmental stage when rigor is incorporated into the curriculum (p. 13). Various participants communicated evidence of this teaching style. T2 and T3 discussed the implementation of rigor and carefully planned lessons. T3 stated cycling through topics through “various assessments and scaffolding of lesson plans…increasing problem difficulty, asking
them why or how to increase thinking” and T2 in agreement stated, “I make sure to scaffold my lesson, I start with basic questions and through the lessons steps get added and get harder.” T1 additionally commented on the increased difficulty through the lesson plans “I teach the basics over one or two problems, then I have them discuss and talk through the steps with me. As we keep going the problems get harder but they start understanding the concepts and content from the beginning and get stuck up on the harder steps. Basically, the skills constantly build as we go through the lesson, growing from easier to harder.” T4 and T5 also made comments regarding careful planning and challenging students, making all five teachers supporting careful planning and increased difficulty throughout lessons as an academic strategy. Administrators also supported increased difficulty across instruction, A1 stated “each assignment should challenge them to a deeper level of thinking and learning”.

Merrill’s First Principles of Instruction Theory suggest that the most effective instructional strategies that increase learning include: 1) a problem-centered focus, 2) activation of prior experience, 3) demonstration of skills, and 4) integration of these skills into real-world activities (Merrill, 2002, 2007). These phases and principles are used to select and design effective instructional strategies such as implementing higher rigor into curriculum (Merrill, 2007). These principles are used to select and design effective instructional strategies such as implementing higher rigor into curriculum (Merrill, 2007). All four of Merrill’s First Principles of Instruction were highlighted in examples during the interviews and focus groups. All teachers and administrators highlighted the importance of problems in the mathematics classroom, thus supporting a problem-centered focus. T1 and T3 specifically spoke to utilizing prior knowledge. T1 stated shifting the lesson to harder concepts “challenges students to apply prior knowledge and build upon it to strengthen the concepts.” T3 discussed how students are encouraged to
discover new content “I also have them use previous knowledge to learn new concepts by asking them questions rather than them asking me, they are forced to recall information.” The third principle, demonstrating skills was also highlighted as an importance among teachers and administrators, all teachers spoke to showing students how to do problems and then allowing them to practice the concept in some form. Specifically, T2 stated “I do a lot of demonstration, and then have them mimic what I did”. Both administrators stated the importance of students seeing what was required. A2 commented on the importance of all the class examples for student comfort “so they don’t blank on the skills when asked to perform them.” A1 responded that students “need to be guided through examples and see what the result should be before they are expected to do it.” Last, integrating the skills into the real-world, teachers and administrators all believe applying these skills are preparing students to succeed in the real-world and become ready for college mathematic classes. The goal of the college preparatory environment is to prepare students to apply the skills in college and careers.

The Folk Belief Theory discusses the belief that educators provide high rigorous curriculum to high-advantage students, such as those who attend private schools (Torff, 2014). Curriculum rigor is a significant factor in many achievement gaps, as it has become widely studied that students are more successful when challenged in the classroom (Beard, 2018; Crouch & DeStefano, 2017). One-hundred percent of participants spoke to the importance of rigor and described how rigor is implemented and used in the private school curriculum. In addition, the school faculty handbook, as well as current strategic plan discussed the requirement for teachers to use rigor in the curriculum to challenge and support student needs and growth. The importance of rigor is highlighted across all the school documents that were viewed.
Implementation of rigor was not just communicated as being used in testing categories, but through discussions, class problems, games, activities, and other instructional strategies.

**Conclusions**

Findings of the study allowed the researcher the ability to identify answers to the research questions. Conclusions are presented in this section.

RQ1: How do teachers and administrators describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

Preparing students for college mathematics courses consists of utilizing many diverse teaching strategies that do not solely rely on test scores, as multiple teaching strategies promotes retention. College mathematic preparation is not just decided based on test scores, but the ability to completely understand and be able to use and apply mathematics. Participants described the classroom strategies used to prepare students for college mathematics as a recursive process, where topics and content continually is presented to students with an increased difficulty every time through a variety of tasks and activities. Concepts were reportedly not just seen during one unit, but are utilized and seen throughout the entire year. The continual revisiting of content assists with student retention.

Specifically, teachers and administrators spoke to the importance of learning and understanding how to navigate problems and apply prior knowledge to discover new, unknown problems. Pushing students to discover the material rather than be told directly how to do it creates an environment where students must think critically to reach understanding. Teachers continually are encouraging students to learn at a higher level and grow each day in the classroom. The high expectations set the students up for success through holding them accountable and presenting them with tough curriculum.
Mathematics curriculum resembling the environment of college courses with high amounts of rigor, multiple assessments, and final examinations prepare students for college mathematics courses. Engaging students each day through asking them questions, encouraging them to do problems on the board, and asking them to discuss why solutions are presented the way they are actively presents students with opportunities to self-assess their learning to determine what is needed to reach mastery.

Through the discussions of scaffolding lesson plans and continually revisiting topics staff at the college-preparatory environment are proud of the atmosphere of the school. Through rising above the state mathematics testing averages as well as the state minority graduation rate, the school has positive characteristics that are not comparable to those of public schools.

RQ2: How do mathematic teachers and administrators implement and encourage rigor in classroom instruction?

Rigorous mathematics classroom instructional methods was the primary strategy used by the study participants to maintain student engagement, and promote academic comprehension and retention. Rigor implementation in mathematics promotes critical thinking and confronts students with opportunities to be actively engaged and involved, as challenging students is key to success. Through walking students through the mathematical process and not just presenting the answers, students discover the “why” behind the lesson and are able to understand the in-depth meaning behind it.

Every aspect of the classroom lesson plans was carefully scaffolded to require effort and tenacity by students. Teachers sought to encourage engagement and activities throughout the lesson to keep students actively involved and thinking. In mathematical classrooms, there is often multiple paths or multiple solutions to problems, it takes careful teaching strategies to
assist students in understanding how this happens and what each solution means. Promoting
flexible and open thinking allows students to question their answers and ask if it makes sense.
Rigor is not just how the lesson is taught, but it is how the students start to proceed through the
requirements of the course as well.

Expecting students to learn the mathematical content at a high level and offering support
through the lesson as mindsets and thinking advances encourages student’s growth. Through
mathematics courses students often understand or have the ability to determine what the answer
is or accomplish the task, but they feel overwhelmed with the complex process. Through rigor
and scaffolding, students would be walked through this process as information is built up so the
overwhelming feeling starts to diminish, and students build confidence in themselves and the
process.

Specifically speaking to instructional strategies participants seemed proud to report on
the diverse teaching strategies used to encourage rigorous classes. Group work, discussions,
games, exit tickets, continual reviewing, and increasing difficulty through lessons were all
mentioned as ways rigor is implemented. Also noted is the benefits of rigor in regular and
honors courses, rigor is not simply just for advanced students, but beneficial to all levels of
learners. The diverse and challenging teaching strategies encourages academic growth and
understanding for all students in the classrooms.

Administrators additionally spoke to the requirement of implementing a set number of
assessments and requiring teachers to utilize multiple classroom strategies to promote the
challenging environment. Effective assessment is beneficial as a method to inform the teacher
and the students of progress and understanding, as well as give the teacher feedback regarding
what lessons or concepts may need further clarification. Effective rigorous instruction is
composed of quality, well thought out tasks with meaning and purpose. Involving and engaging students through the rigorous methods in the class promotes engagement and involvement, thus benefitting student learning.

RQ3: What are the foundational concepts that mathematics teachers and administrators use to assess college readiness of high school students?

At the college preparatory school, teachers and administration are continually assessing the mathematical college readiness of students throughout the four years in high school. Three common characteristics that were discussed to play a factor in college readiness are cognitive strategies, content knowledge, and self-management skills. Additionally, the documents reviewed from the state and school support the goals in preparing students for college and assuring support is provided to accurately reach college readiness goals. Specific factors that are considered to address and determine if students are prepared for college are giving students multiple assessments, introducing students to finals and the study skills to be successful on those, the ability to succeed and develop the skills to succeed in higher-level, challenging courses, and being responsible for learning in their education.

Cognitive strategies in mathematics courses encourages students to think about the way they learn and the process to understanding a solution, not just the final answer. If students can formulate, investigate, and think about possible solutions to problems and understand why the specific conclusions are being drawn success is in sight. The ability to evaluate material and think analytically and logically while comparing and contrasting different methods expands student mindsets past the simple right or wrong answer. Learning must be extended and have the capabilities of being applied to all aspects of instruction, not just one specific lesson.
Content knowledge is an additional factor, to succeed in collegiate mathematics classes, students must have the basic skills and understanding to begin those classes. Specific knowledge must be obtained prior to entering college courses to be successful in higher level courses. Through rigorous coursework and multiple teaching strategies it is hopeful that in high school students will gain the proper content knowledge to be prepared. Supported by state documents, there are state specific requirements in mathematical content areas that students are required to know to be deemed as college ready. The set of key concepts assists in helping students develop their understanding in a way that postsecondary education can build on.

Specifically, supported by participants, assessments and test scores are key indicators to determining if students are understanding the content and the mathematical process. A successful school is lead and organized by the administrators, and the teachers implement the requirements following the policies set forth to prepare students for graduation and college. Mathematics curriculum reflecting that of college courses with high amounts of rigor, multiple assessments, and finals prepare students for college mathematic courses. Assessments aim to enhance mathematics learning and support good instructional practice. At college, many students encounter final exams for the first time, and unfortunately, many students struggle in the ways to prepare and get ready for a test consisting of material from an entire semester. Introducing high school students to finals allows study skills and accountability measures to be developed through the high school years. The multiple assessments leading to finals allows students to actively and routinely be assessed to check progress and retention. When students perform well on the final exams and are able to retain information through study strategies and develop a deep understanding of the material, administrators and teachers start to see college like characteristics and motivation factors in the students.
Seeing self-management and motivation factors in students shows that students are maturing and organizing themselves in a way that will be of benefit through their college careers. Participants reported student taking responsibility for their grades, learning, and coursework. Students are coming in for help when needed, seeking out support services, and planning out their weeks to allow time to study and prepare for upcoming assessments. Many of these skills are not developed until college years, it is reassuring that students in this high school environment are already taking measures to academically and mentally prepare for the requirements of college mathematics education.

Implications

The study yielded findings that have implications for practice. Discussion of implications of the study are presented in the following section.

Importance of Productive Struggle in Mathematic Instruction

As a method to guide student mathematical understanding and comprehension, participants indicated that designing mathematics curriculum which allows students to struggle as a form of discovery is a main component of instruction. The National Council of Teaching Mathematics supports this logic by stating that effective mathematics teaching involves supporting students as they productively struggle (NCTM, 2018). After the analysis of participant interviews and focus groups, it was shown that all seven participants discussed how challenges are presented to students through instructional strategies.

In some form, all teachers and administrators have used a variety of challenging classroom activities to promote critical thinking at a higher level. T4 compared the mathematics classroom to Blooms Taxonomy relating the beginning of the chapters to the lower part of the ladder, and the end of the chapter to the top. Students are challenged and allowed to struggle
through a variety of different tasks and assignments as they work their way to mastery. Each participant had a distinct way to incorporating productive struggle, and each spoke that it does not solely require harder problems, but comes from the requirements and tasks involved in the lessons. Asking students questions about the mathematical process, or why a solution ended up being a certain type of number are all ways to increase critical thinking. Mathematics is not solely based on the final answer, but the process to get to the end result.

It is also notable that while all participants were in agreement that having a challenging, difficult mathematics curriculum and instructional practices is beneficial to learning, they all additionally support and guide students if the struggle gets to be too much. T5 spoke to how teachers are there to continually help students through difficult times, noting that some students are self-motivated and enjoy the challenges, but some also shut down and get frustrated. This reflects the teacher and administrator role in encouragement and assuring that the struggle is being productive and not inhibiting learning or causing students to give up on tasks. A3, an administrator, also supported the influence of teachers discussing the important role teachers play in assisting students to be successful discussing teachers are the students guide to success.

**Necessary Balance of Mathematical Conceptual Understanding with Skill Acquisition**

Understanding the process and skills required for mathematical concepts is an important aspect of learning. The shift to a rigor-filled mathematical environment encourages a diverse instructional environment full of strategies to encourage conceptual understanding, procedural skill and mathematical fluency, problem solving skills, and application (Wu & An, 2016). Participants indicated that involving and engaging students in the process of solving equations and understanding the concepts leads students to mastery and complete understanding. All five
teachers attributed the importance of the mathematical process, and one administrator who has a mathematics background additionally supported the understanding of the process.

Building skills through the lesson and continually using previous knowledge was a key indicator of the scaffolding that goes into understanding the mathematical procedures. Encouraging engagement and utilizing the cycle of learning was continually mentioned as teachers discussed how if students do not completely understand the process of a problem, the end result will never be correct. Challenging students to discuss, or even talk through the topics and skills needed helps students continually see and revisit skills to reach mastery.

Focusing on mathematics college readiness, teachers addressed the desire to assure students remember the process as they continue to college level mathematics. T4 discussed how students can often complete one type of problem, however, if that same problem is presented in a word form rather than an equation form, students struggle. Teaching students the skills needed to apply their knowledge in any situation or scenario assists in conceptual understanding. In mathematics many steps and procedures are often involved, while T1 discusses how if students get lost or stuck in the process it is not always a bad aspect of learning. When students have incorrect answers but show all steps T1 looks at the process and is able to see where students get stuck or what specific concept or skill is presenting an issue. Often the error is correcting the understanding of one minor step, not having to reteach the entire concept. In mathematics courses skills from previous years are always used to support new learning. Concepts from early mathematics classes get used again in future classes and even college level courses, hence the desire to encourage student mastery regarding mathematical skills and processes.
Connection of Continuous Assessment to Mathematic Content Mastery

A school requirement and practice supported by teachers and administrators is the continuous assessment of students to assure content mastery. Iqbal et al. (2018) concluded that mathematics teachers in private school environments have better assessment and classroom practices. In addition, most private secondary school boards require more challenging assessments and grading scales as most hold the label as college-preparatory environments, which adequately prepare students for college education (Barnett, 2016). The number of formative and summative assessments are generally significantly higher in private schools, as assessment promotes learning (Xiao, 2017). Each teacher and administrator discussed the benefits of the required assessments to encourage student learning and retention. Through the summative and formative assessments students are given plenty of feedback on progress which highlights deficient areas that need attention.

Through the data teachers addressed the ability of the assessments to prepare students for college, as much of collegiate classes include many, if not all assessments for grading. Having students experience an environment with multiple tests and quizzes allow them to learn how to prepare and study for assessment scenarios. T5 communicated that positive feedback has even been received from students regarding the liking of the smaller assessments, as it gives students the opportunity to check their understanding prior to larger exams and assessments. The curriculum continually challenges students, discovering where students are struggling and with what material helps the student as well as the teacher. Students learn how to use the feedback provided by the teachers, and teachers understand what material provides barriers to content mastery leaving the ability to reteach if needed.
Speaking to the higher AP and ACT scores of the school, the administrators addressed that the students are prepared for higher exams due to the schools’ requirements. According to A2, the assessments assist in helping students develop studying techniques, this carries over to assessments for the course and eventually into college. Additionally, a common topic was the fact that the school has finals, much like a college environment. This also requires students to retain and fully understand and master content, as it must be used at the end of the semester to pass the exam.

As stated by A1, the students are getting plenty of opportunities to assess their learning and gain feedback. Students do not have to fail a test to know that the material was not understood or learned, there are plenty of indicators along the learning path to give warning signs that additional help or support is needed. The goal in each classroom is to prepare students with the knowledge and understanding that can be carried over to college and applied in future courses and careers. A2 states that it is evident through the higher level testing scores that for the most part, students are learning the material and retaining the knowledge in order to perform well on college-preparatory assessments, as the schools test scores are much higher than the state and area averages. Additionally, A2 shared that she thinks the higher test scores are a direct result of the testing requirements at the school. Frequent assessments force the students to be prepared, continually study, and hold themselves accountable to succeed.

**Variation and Customization of Mathematical Instructional Practices**

The rigor present in the private school of study mathematics department was evident through the discussions held with participants regarding the instructional practices used. All five mathematics teachers shared unique classroom strategies that support and enhance student learning, and each administrator discussed the instructional strategies encouraged to promote
student success. Diverse mathematical teaching strategies assist in creating an environment that requires different types of thinking and skills, promoting critical thinking and problem solving (Awofala & Lawani, 2020). Customizing instructional practices helps address the wide range of abilities that students may have in a classroom.

Commitment to providing students with the best instructional practices to encourage student growth in the content area of mathematics was evident through the data. The diverse strategies included in discussions entailed increased difficulty through the lesson, group work, customized instructional booklets, discussions, games, challenge questions, student-led lessons, and various types of assignments. It is also noted that while teachers did state they lecture for a portion of the class period, that a lecture does not compose the entire hour, additional activities or instructional practices are reportedly always used to support learning and promote student engagement.

Through the various classroom styles, rigor is a common factor used to guide the decisions made by the teaching staff in hopes to solidify the mathematical content students are learning. Each teacher and administrator addressed the need for mathematical rigor and how it is utilized in an effective way in the classroom. Speaking to the idea that rigor is not just more challenging problems, T3 discussed that rigor is implemented through assignments, lesson plans, finals, student interactions, and other ways to increase thinking. The administrators additionally spoke to how the idea of rigor is making students think differently, expand on knowledge, and be engaged to promote learning and retention.

Additionally, the participants tied mathematical instructional strategies into preparing students for college. Addressing mathematic college readiness, the results determined that the high expectations of the classrooms and the rigor used resemble that of college mathematic
courses. Continually assessing students’ knowledge and circling back to topics to prepare for final examinations reflects the encounters students will have in future collegiate classes. Expecting students to excel and succeed is encouraged from all teachers, as the knowledge presented to students is not just learned for a test and forgotten, but mastered and applied in life.

**Recommendations for Future Research**

The following recommendations are offered for related research in the field of collegiate mathematical readiness:

1. Since this study was set in a smaller private school, a study of larger private school districts to determine if the graduation difference in minority groups remains higher than the state averages may add to the understanding of the influence rigor has on college mathematic readiness.

2. A comparative study of private and public-school instructional strategies focusing on the supports used to promote college readiness.

3. A further investigation regarding mathematic college readiness of high school students from the mathematic college faculty perspectives comparing students who come from public schools and those who come from private schools.

**Summary**

This study offered a qualitative perspective on the important phenomenon of using rigorous instructional strategies in private school environments to prepare students for college mathematics courses. Findings of the study revealed ways that teachers implement and encourage rigor and assess college readiness. In summary, it is noteworthy to consider the role private high school educators have in academically preparing students for college courses.
References


Brahier, D.J. (2013). Teaching secondary and middle school mathematics (4th ed.).


Graham, S., & Perin, D. (2007). Writing next-effective strategies to improve writing of adolescents in middle and high schools


Heo, H., Lim, K. Y., & Kim, Y. (2010).


Kruger, P. (2018). Why did the approach to teaching math change with common core?


McNulty, R. J., & Quaglia, R. J. (2007). Rigor, relevance and relationships. School Administrator, 64(8), 18.


Minke, T. A. (2017). Types of Homework and Their Effect on Student Achievement.


MDE. (2020). Minnesota Department of Education Strategic Plan.


Moore, A. (2019). What Are The Doorways And Barriers To Enrollment In College Preparatory Courses For Students Who Are Black, Hispanic, And American Indian?.


Pfrenger, W., Blasiman, R. N., & Winter, J. (2017). "At First It was Annoying": Results from Requiring Writers in Developmental Courses to Visit the Writing Center. Praxis: A Writing Center Journal.


Rosenshine, B. (1997). The case for explicit, teacher-led, cognitive strategy instruction. MF Graves (Chair), What sort of comprehension strategy instruction should schools provide.


School of Study (2020). Strategic Plan.


Smith, B. (2018). Generalizability in qualitative research: misunderstandings, opportunities and recommendations for the sport and exercise sciences, Qualitative Research in Sport, Exercise and Health, 10:1, 137-149, DOI: 10.1080/2159676X.2017.1393221


Preparing Students for College and Careers: Theory, Measurement, and Educational Practice.
Dear Faculty/Administration Member:

My name is Nichelle Guillaume, and I am a doctoral candidate in the Doctor of Education Program at Winona State University. I would like to invite you to participate in a research study I am conducting for my dissertation.

The purpose of this study is to explore the perspectives of those in private school environments on the instructional strategies and rigor used to improve high school student college mathematic readiness. I invite you to participate because you are currently serving as a faculty or administration member in a private school environment.

Your participation will involve a 30-60 minute online interview using a Survey Monkey questionnaire and possible follow-up emails for clarification, if necessary. I will also conduct a 1-hour focus group with all mathematics department staff involved or one-on-one interviews for any administration involved either in person or over online conferencing software. For full disclosure, the focus group and one-on-one interview session will be recorded so I can accurately transcribe and analyze what is discussed. You will be also asked to provide your current course syllabi for a document review conducted entirely by the researcher.

Participation is voluntary, and you may withdraw from the study at any time without consequences. You may answer as little or as many questions as you desire. Clicking on the survey link serves as your consent to participate. Your original consent form will be placed under lock and key, separate from your reported responses to protect anonymity. Feedback and responses will remain confidential to the fullest extent permitted by law.

For the purpose of this study, and to maintain anonymity, a code will be created and assigned to each participant. The transcripts of the interviews will be kept separately from the codes stored in a secured file cabinet located in a locked safe. Once the study has been completed, all data will be kept for seven years, after which time all information will be destroyed.

Thank you for your willingness to participate in this research study. If you have any questions or concerns, please feel free to email me at ngrage16@winona.edu or call me at (507) 383-9607. The faculty sponsor of this study is Dr. Barbara D. Holmes. Email bholmes@winona.edu

Respectfully yours,
Nichelle Guillaume
Doctoral Candidate
Winona State University
APPENDIX B

CONSENT FORM

Consent Form:
Instructional Strategies and Rigor: Private School Perspectives on Improving Minnesota’s College Mathematic Readiness

What is this research study about?
You are invited to participate in a research study designed to explore the perspectives and experiences of mathematics faculty and administration on rigor in instructional strategies for improving high school student college mathematic readiness.

What activities will this study involve?
If you decide to participate, you will be asked to participate in an individual interview or focus group, and provide course syllabi for a document review. The individual online interview will last approximately 30-60 minutes and the online focus group will be scheduled for 60 minutes. Prior to interviews participants will be asked to complete an online Survey Monkey interview asking for educational background information.

How much time will this take?
The study will begin on December 10th and end on December 20th. Individual interviews will be scheduled via Zoom or in person based upon participant’s availability and preference. The focus group will be scheduled during the mid-week of December. I estimate participating in the study will require 2 hours of your time.

What will be done with the data collected during this study?
The only individuals that will have access to the data are the researcher, dissertation chair, and advisory committee. The Family Educational Rights and Privacy Act (FERPA) requires the confidentiality of your information with this study and will be adhered to. Your identity will remain protected and confidential, and ethical standards will be adhered to. The signed consent will become part of the research documents. You may request a copy of this consent at any time. Each participant will be assigned a code to protect anonymity. When participants log on Zoom, they will have the code listed as their identity and not their name. Participants will be asked to have their cameras off to further protect identity. The computer utilized for data collection has password protected and has anti-virus software.

All information collected will be stored in a locked cabinet in a safe in the researcher’s home. When the study is completed, data will remain in a locked cabinet for seven years and then professionally shredded.

Are there any risks for participating?
There are no appreciable risks from participating in this study to health and safety. The only risk posed is Zoom having access and rights to the video recordings, however the identities of participants will remain confidential over Zoom through using codes and keeping cameras off.

Are there any benefits to participating?
The benefit of the study is to add to the body of literature providing guidance to future educators.
What are my rights as a participant?
Participation in this study is voluntary, and you may stop at any time. You may decide not to participate or to discontinue participation at any time without penalty.

Who can I contact if I have questions or concerns about this study?
The main researcher conducting this study is Nichelle Guillaume, a student at Winona State University. Dr. Holmes is the faculty advisor for this study. Dr. Holmes may be reached at bholmes@winona.edu or (507) 457-5651. You may ask any questions you have about the study and your participation now or later during the study.

Who can I contact if I have questions about my rights as a participant?
If you have questions or concerns about your participation in the study, contact the Human Protections Administrator Brett Ayers at 507-457-5519 or bayers@winona.edu. This project has been reviewed by the Winona State University Institutional Review Board for the protection of human subjects.

You will be given a copy of this form to keep for your records.

**Agreement to Participate**
Participation in this study is voluntary. You may withdraw at any time without any consequences. Your signature indicates that the study has been explained, you have had an opportunity to ask questions, and you have decided to participate.

Your signature: ________________________________ Date _______

Your name (printed): ________________________________

Signature of person obtaining consent: _______________ Date __________

Name of person obtaining consent (printed): ________________________________
Welcome, and thank you for your participation in this research study interview. My name is Nichelle Guillaume, and I am a doctoral candidate in the Doctor of Education program at Winona State University, Winona, Minnesota. I am conducting research for my dissertation study. The purpose of this study is to explore the perspectives of those in private school environments on the instructional strategies and rigor used to improve high school student college mathematic readiness. This Survey Monkey online interview will take approximately thirty to sixty minutes and includes questions about you, your educational background, current courses teaching, and perspectives from your teaching experience. Identities will remain anonymous, and a code will be assigned to each participant. No collection of IP addresses will be collected. You may opt to discontinue the questionnaire at any point during the interview. Responses will remain confidential at all times. Your contribution to the study may provide insight into best-instructional strategies of mathematics faculty with altered educational options promoting student success. You are granting consent by clicking on the interview link. The original copy of the informed consent will be placed under lock and key, separate from your reported responses. Participation is completely voluntary, and you may withdraw your participation at any point without consequences.

Three research questions will guide this qualitative study:

RQ1: How do teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

RQ2: How do mathematics teachers implement rigor in classrooms?
RQ3: What are the foundational concepts that mathematics teachers use to assess high school students’ college mathematic readiness?

**Questionnaire questions**

1. What is your gender?
2. What is your race?
3. What is your age?
4. How many years have you taught?
5. What mathematics classes are you currently teaching?
6. What mathematics courses have you previously taught?
7. What is your highest educational degree?
8. What are your thoughts on the mission regarding academics in a private school?

Thank you for your participation in this study.
APPENDIX D

INDIVIDUAL INTERVIEW PROTOCOL

Individual Interview Protocol

Welcome, and thank you for your participation in this research study focus group. My name is Nichelle Guillaume, and I am a doctoral candidate in the Doctor of Education program at Winona State University, Winona, Minnesota. I am conducting research for my dissertation study. The purpose of this study is to explore the perspectives of those in private school environments on the instructional strategies and rigor used to improve high school student college mathematic readiness.

This individual interview will take approximately 60 minutes and include questions about your experiences as an administrator and your views on implementation of a rigorous instructional curriculum. For the purpose of this study, and to maintain your anonymity, a code will be assigned to protect your identity. No IP addresses will be collected. If at any time during the focus group you wish to discontinue, you may do so. Your responses are and will remain confidential. Your contribution to the study may provide insight on strategies to high school student college mathematic readiness.

Participation in this focus group is voluntary, and you are free to answer as many or as little questions that you desire. The session will be audio-recorded to ensure that no data is missed in the report. Your camera will remain off, and your name will be a code. Please note that Zoom has a disclaimer they own rights to the recording.

The session will be structured so individuals can respond to each question in order of assignment based upon your identification code. Each question will be addressed in the same order to ensure each participant answers each question (round-robin). Upon completion of all participants answering, additional time will be provided for all individuals to provide additional information, if desired.

Your participation in the focus group is voluntary, and you may withdraw your participation at any time without consequences.

Three research questions will guide this qualitative study:

RQ1: How do administrators and teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

RQ2: How do administrators and mathematics teachers implement rigor in classrooms?

RQ3: What are the foundational concepts that administrators and mathematics teachers use to assess high school students’ college mathematic readiness?
Interview Questions:

1. How do you encourage teachers to engage and challenge students and keep them interested during instruction?

2. How do you encourage the employment of mathematical instructional strategies in the classroom?

3. How do you motivate students to exceed expectations and continually challenge themselves?

4. Have you ever been an administrator in a public school district? If so, can you discuss any difference between the expectations and abilities of students?

5. Do you feel like graduating high school students are prepared for college mathematics courses?

6. Do you believe it is important to push students to learn more and understand the presented information? If yes, why? If no, why?

7. What approaches do you take to assure the differentiation of instruction to accommodate varying comprehension levels and understanding are taking place when planning a lesson?

8. Can you explain activities or teaching tricks that get more out of students?

9. What are some of the indicators that you use to determine if a student is progressing towards college and career readiness in mathematics?

10. Do you feel like your instructional approaches align with college expectations?

11. Can you explain how the high school mathematics curriculum prepares high school students for college-level coursework?

12. Would you like to share any additional information about how you encourage teachers to prepare students for college-level mathematics coursework?

Thank you for your participation in this study.
APPENDIX E

FOCUS GROUP PROTOCOL

Focus Group Protocol
Welcome, and thank you for your participation in this research study focus group. My name is Nichelle Guillaume, and I am a doctoral candidate in the Doctor of Education program at Winona State University, Winona, Minnesota. I am conducting research for my dissertation study. The purpose of this study is to explore the perspectives of those in private school environments on the instructional strategies and rigor used to improve high school student college mathematic readiness.

This focus group will take approximately 60 minutes and include questions about your experiences as a mathematics faculty member in teaching a rigorous instructional curriculum. For the purpose of this study, and to maintain your anonymity, a code will be assigned to protect your identity. No IP addresses will be collected. If at any time during the focus group you wish to discontinue, you may do so. Your responses are and will remain confidential. Your contribution to the study may provide insight on strategies to high school student college mathematic readiness.

Participation in this focus group is voluntary, and you are free to answer as many or as little questions that you desire. The session will be audio-recorded to ensure that no data is missed in the report. Your camera will remain off, and your name will be a code. Please note that Zoom has a disclaimer they own rights to the recording.

The session will be structured so individuals can respond to each question in order of assignment based upon your identification code. Each question will be addressed in the same order to ensure each participant answers each question (round-robin). Upon completion of all participants answering, additional time will be provided for all individuals to provide additional information, if desired.

Your participation in the focus group is voluntary, and you may withdraw your participation at any time without consequences.

Three research questions will guide this qualitative study:

RQ1: How do teachers describe the mathematical instructional strategies used to prepare secondary students for college mathematic courses?

RQ2: How do mathematics teachers implement rigor in classrooms?

RQ3: What are the foundational concepts that mathematics teachers use to assess high school students’ college mathematic readiness?
Interview Questions:

1. How do you engage and challenge students and keep them interested during instruction?

2. How do you employ mathematical instructional strategies in the classroom?

3. How do you motivate students to exceed expectations and continually challenge themselves?

4. Have you ever taught in a public school district? If so, can you discuss any difference between the expectations and abilities of students?

5. Do you feel like graduating high school students are prepared for college mathematics courses?

6. Do you believe it is important to push students to learn more and understand the presented information? If yes, why? If no, why?

7. What approaches do you take to differentiate instruction to accommodate varying comprehension levels and understanding when planning a lesson?

8. Can you explain activities or teaching tricks that you employ to get more out of students?

9. What are some of the indicators that you use to determine if a student is progressing towards college and career readiness in mathematics?

10. Do you feel like your instructional approaches align with college expectations?

11. Can you explain how the high school mathematics curriculum prepares high school students for college-level coursework?

12. Would you like to share any additional information about how you prepare students for college-level mathematics coursework?

Thank you for your participation in this study.
APPENDIX F

RESUME

Nichelle M. Guillaume
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RESEARCH INTERESTS
Mathematical instructional practices, Rigor and assessment, College readiness, High School student success

EDUCATION
Doctor of Education, Winona State University, 2021 (Anticipated)
Master of Science, Education, Winona State University, 2018
Graduate Certificate, Teacher Preparation Collaborative, Winona State University, 2017
Bachelor of Science, Mathematics, University of Wisconsin-La Crosse, 2015

PROFESSIONAL EXPERIENCE

MATHEMATICS TEACHER 2019-
Lourdes High School, Rochester MN
• Teach and develop high school mathematics coursework in Pre-Calculus, Statistics, and Algebra 2.
• Prepare students for future college study.

MATHEMATICS TEACHER 2018-2019
Mayo High School, Rochester MN
• Long-term substitute teaching and developing Geometry coursework.
• Prepared students for academic growth and success.

MATHEMATICS, SCIENCE, AND ART TEACHER 2017-2018
Mabel-Canton Middle and High School, Mabel MN
• Teach and develop high school and middle school mathematics, science, and art curriculum and coursework.
• Provided students with necessary knowledge to succeed in various content areas.

MATHEMATICS TEACHER AND PARAPROFESSIONAL 2015-2017
Caledonia High School, Caledonia MN
• Provided instruction to Geometry and Algebra 2 students through interactive teaching methods.
• Provided support and assistance to special education students through implementation of 504 and IEP plans.
**PUBLICATIONS**


Holmes, B., Boulton, B., Boysen, B., Perry, C. L., Bailey, D., Durnen, A., Mollner, J., De La Fosse, K., Sinning, M. W., Guillaume, N., Breuninger, R., Jones, S., Webber, S.. (2019). Doctoral student perspectives on motivation and persistence: Eye-opening insights into the ideas and thoughts that today's doctoral students have about finishing the doctoral degree. *Education Doctorate Books*. 1. [https://openriver.winona.edu/educationeddbooks/1](https://openriver.winona.edu/educationeddbooks/1)

**CONFERENCE PAPER PUBLICATIONS**