A Comparative Study of Students' Scores in Eighth-Grade Algebra 1 for Students Who Participated in a Seventh-Grade Rigorous Preparation Program and Those Who Did Not Participate at a Selected Junior High School in Tennessee

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Abstract

The purpose of this study was to compare students who participated in a rigorous seventh-grade Algebra 1 preparation program to those who did not participate at a selected junior high school in Tennessee. This comparison included several measures of achievement including semester 1 eighth-grade Algebra 1 grades, Algebra 1 benchmark scores, and Algebra 1 benchmark subscores (quantities, expressions and equations, linear functions, modeling linear functions, and quadratic and polynomial functions). The sample consisted of one eighth-grade Algebra 1 class where ten students completed sets of rigorous challenge questions accompanied by teacher feedback during their seventh-grade math class while the other eleven did not. All students in the sample participated in eighth-grade Algebra 1 during the fall semester. Data were collected at the end of the semester in the form of students' semester 1 Algebra 1 grades and scores from two Algebra 1 benchmarks. Data were then analyzed using independent t-tests. The results indicated that there was no significant difference in students' semester 1 grades, benchmark scores, and benchmark subscores between those who participated in the rigorous preparation program and those who did not. The results suggest that the rigorous preparation program may require adjustments in the instructional setting, format, and teacher feedback for it to have a more significant impact on students in eighth-grade Algebra 1.

Keywords: eighth-grade Algebra 1, feedback, rigor, higher-order thinking, critical thinking

Chapter 1

Introduction

Eighth-grade Algebra 1 has become a common course among middle schools across the United States over the last several decades. In the 1980s, the National Council of Teachers of Mathematics (NCTM) prompted a shift in mathematics which promoted problem solving rather than rote memorization and emphasized that pre-college math courses should be characterized by higher-order thinking skills such as making conjectures, justifying one's thinking, and making arguments (Research Advisory Committee of the NCTM, 1988). With this shift in standards, the possibility of taking eighth-grade Algebra 1 has opened up to more students (Spielhagen, 2006). Algebra has been described as the "gatekeeper to more advanced courses in both mathematics and science" (Spielhagen, 2006). Thus, when students take Algebra 1 early, they have the possibility to take higher-level course offerings in high school and in turn may be more prepared for college.

Several studies have looked at the benefits of eighth-grade Algebra 1. Spielhagen (2006) conducted a study which focused on a large southeastern school district where eighth-grade algebra was offered at all eleven of its middle schools. Researchers compared the group who took eight-grade Algebra 1 to those who did not. Additionally, they included a comparison between students of similar math achievement (as of the end of their seventh-grade year) who took eighth-grade Algebra 1 versus those who took Algebra 1 in ninth grade. Spielhagen (2006) found that students who took eighth-grade Algebra 1 on average took a larger quantity of math courses in high school as well as higher-level math courses. These students also attended college at higher rates than the groups who did not take eighth-grade Algebra 1. In a similar study, Lee and Mao (2021) also examined how taking Algebra 1 before high school is associated with

student math achievement and which math courses students take throughout high school. This study used a much larger and more representative sample of 15,390 students from across the United States as opposed to Spielhagen's (2006) data from one large school district (Lee & Mao, 2021). Lee and Mao (2021) found a positive significant relationship between taking Algebra 1 before high school and students' achievement scores and high school math courses. More specifically, students who had taken Algebra 1 before high school scored significantly higher on ninth- and eleventh-grade math achievement tests than students who did not take Algebra 1 until high school. Depending on the statistical model, students from the sample who took Algebra 1 before high school had a 14%-29% higher likelihood of taking Calculus or higher in high school than students who waited until high school to take Algebra 1.

While the benefits of taking Algebra 1 before high school can be positive, studies have show that the way eighth-grade Algebra 1 programs are implemented and the students who take them are also important factors to consider. Clotfelter et al. (2015) studied two large North Carolina school districts which implemented early algebra programs for all students. When the policy was implemented in these school systems, no changes were made to the previous math courses students took. Clotfelter et al. (2015) used a control group made up of four school districts which continued to offer eighth-grade Algebra 1 to students who met certain conditions rather than applying the algebra-for-all policy. They found that when students were accelerated to eighth-grade Algebra 1 but the curriculum for previous math courses were not reformed to meet the demands of taking Algebra 1 early, then students showed significantly lower performance on Algebra 1 and Geometry End of Course (EOC) tests (Clotfelter et al., 2015). Similarly, in his investigation, Loveless (2008) found that there was no correlation between eighth-grade National Assessment of Education Progress (NAEP) scores from 2007 and

advanced enrollment in Algebra 1. This means that just because a state had a higher enrollment in Algebra 1 before high school does not necessarily mean that those algebra students performed better in mathematics. These studies demonstrate that while taking Algebra 1 before high school can be beneficial and open up doors to higher-level math courses, it is essential to consider if students have taken courses which prepare them for the demands of eighth-grade Algebra 1 and have the background skills necessary to succeed in this course.

In an attempt to strike a balance between eighth-grade Algebra 1 for a select few and an algebra-for-all policy, the Wake County Public School System (WCPSS) in North Carolina developed a policy which assigned students to math classes in middle school, including eighth-grade Algebra 1, by using the Education Value-Added Assessment System (EVAAS) to measure and determine which students were eligible for accelerated math courses (Dougherty et al., 2015). Their goal was to reduce bias in teacher recommendations for accelerated math courses and to promote equity in which students were given the opportunity to take these courses. Dougherty et al. (2015) found that after this policy was implemented, the number of students taking accelerated math courses increased. Generally, underrepresented populations were more proportionally represented in the accelerated math courses with the new policy than they previously were without the policy. From Clotfelter et al. (2015), Loveless (2008), and Dougherty et al. (2015), it is important to draw the conclusion that how students are prepared for eighth-grade Algebra 1 matters and equitable access to early algebra can be achieved by using measures to determine which students are ready for eighth-grade Algebra 1, rather than just trying to meet a quota for minority students in the course.

In this study, two groups of eighth-grade Algebra 1 students were compared. One group completed a rigorous Algebra 1 preparation program their seventh-grade year while the other

group did not. The preparation program included students completing sets of challenge questions for each unit in seventh-grade math. While these questions were based on the Tennessee seventh-grade math standards, they went above and beyond what students learned in the general seventh-grade math classroom. The questions gave students the opportunity to problem solve, think critically, justify their solutions, and make generalizations. After completing each set of challenge questions, student received extensive teacher feedback and were asked to review the feedback so they could continue to grow in their thinking about mathematics. Thus, two other areas which were important to consider within the context of this study were critical thinking skills associated with a rigorous curriculum and teacher feedback.

It was clear from the literature on eight-grade Algebra 1 that students who were prepared for eighth-grade Algebra 1 could reap the benefits associated with taking Algebra 1 before high school. This leads one to examine how can students be better prepared to meet the demands of eighth-grade Algebra 1. Elder and Paul (2010) state that as students develop critical thinking skills, they become better learners. They also note that as students engage in critical thinking, they develop their skills to "raise vital questions and problems…, gather and assess relevant information…, come to well-reasoned conclusions and solutions…, think open-mindedly with alternative systems of thought…, and communicate effectively with others in figuring out solutions to complex problems" (Elder & Paul, 2010, p. 38). Similarly, McCollister and Sayler (2010) state that critical thinking supports academic achievement, and it helps students better analyze what they are learning. They also note that high-achieving students, especially gifted students, need rigorous learning environments which help stimulate their thinking and help them grow academically (Elder & Paul, 2010). These gifted students are often those who are poised to take eighth-grade Algebra 1. Thus, it is important to consider how these students can be

challenged so they may continue to be pushed academically. Smith and Szymanski (2013) note that higher-order thinking questions result in the development of critical thinking skills. To encourage higher-order thinking questions, teachers can ask questions which are more divergent in nature (Smith and Szymanski, 2013). This means that rather than leading to a single answer, divergent questions lead to multiple answers and more creative responses. These critical thinking skills and higher-order questions were embodied in the rigorous seventh-grade preparation program for Algebra 1. Thus, it was important to determine if there was a significant difference in students who engaged with questions which were intended to build their critical thinking skills and those who did not.

One of the hallmarks of the rigorous preparation program was teacher feedback. Students were not simply told which questions they answered correctly or incorrectly. They were provided with feedback for how to better approach problems they solved incorrectly as well as feedback on how to improve correct solutions. There is abundant research on teacher feedback and how to provide students with quality feedback. Núñez et al. (2015) indicated that as students progressed in school (from middle school through high school), they perceived that the amount of feedback they received on homework decreased. Thus, middle school and high school teachers may have to be more intentional about providing their students feedback. The question becomes what makes feedback useful and beneficial to students. According to Brookhart (2008), when providing students with written feedback, three main factors should be considered – feedback clarity, specificity, and tone and word choice (pp. 32-36). Brookhart (2008) writes that feedback should "light the way forward" which means the teachers help the student identify what is wrong and suggest how they can do something about it (p. 35). From a meta-analysis on various studies on feedback, Hattie and Timperley (2007) found that information feedback about a task has the

highest effect size out of the various types of feedback analyzed. This is feedback which lets the student know how they can better perform a task. Similarly, Shute (2008) found that specific feedback which targets helping students improve their responses can greatly impact student learning. Additionally, Shute (2008) found that formative feedback provided to students should include a mixture of verification feedback (stating whether a response is right or wrong) and elaboration feedback (elaboration on a specific dimension of the response in order to provide the student with more specific feedback). The feedback students received when completing challenge questions included a mix of verification feedback as well as elaboration feedback like Shute (2008) suggests.

Shute (2008) also found that delayed feedback may help students transfer their learning to new situations and problems. Some benefits to delayed feedback include promoting active cognitive processing, more attention to metacognitive skills, and improved autonomy. The challenge questions provided to seventh-grade math students involved delayed feedback. Students worked on questions for several weeks and then turned in their responses at the end of a unit. They then received feedback a few days after turning in their responses. Since a goal of the challenge questions was for students to be able to transfer their learning of seventh-grade math skills in order to become better problem solvers and to develop critical thinking skills, it was important to determine if there were any differences in students' scores once they moved on to eighth-grade Algebra 1.

Other studies have documented how receiving quality feedback has made a difference in student performance. For example, Núñez et al. (2015) found that there was a significant association between teacher feedback on homework and amount of homework completed as well as amount of homework completed and academic achievement. Thus, teacher feedback on

homework has an indirect relationship with student achievement. Baliram and Ellis (2019) conducted a study which investigated how reflective assessment and content-specific teacher feedback affected student achievement for high school geometry students. They found that there was a statistically significant difference between the experimental group's (those who practiced reflective assessment and received content-specific feedback) and control group's achievement as evidenced by statistical analyses of the pretest, posttest, and retention test. These studies indicated that it was important to consider teacher feedback since it was an essential element of the rigorous preparation program considered in this study.

Statement of the Problem

At a specific junior high school in Tennessee, seventh-grade students are offered the opportunity to take Algebra 1 their eighth-grade year if they meet specific conditions. The student's seventh-grade math grades, scores on a series of four tests which compare their performance to other seventh-grade students interested in the program, and math teacher recommendations are all considered when determining if a student will be a good fit for eighth-grade Algebra 1. Some seventh-grade students who are applying for eighth-grade Algebra 1 are given the additional requirement of completing a rigorous preparation program which includes a series of challenge questions which promote higher-order thinking skills. While students do receive extensive feedback, the challenge questions are ungraded and do not factor into a student's math grade.

The goal of the rigorous preparation program is to offer students rigorous questions which help them develop their critical thinking skills. The hope is that through engaging in these types of questions, students will be more prepared to take eighth-grade Algebra 1. Another major goal of the preparation program is to provide students with detailed feedback on their responses

to higher-order questions so they can continue to develop their problem-solving approaches and thinking skills. One question remained unanswered. Was this preparation program, which included challenge question sets and took considerable time and effort both for students and teachers, making a difference in students' scores when they entered eighth-grade Algebra 1?

Purpose of the Study

The purpose of this study was to compare students who participated in a rigorous seventh-grade Algebra 1 preparation program to those who did not participate at a selected junior high school in Tennessee. This comparison included several measures of achievement including semester 1 eighth-grade Algebra 1 grades, Algebra 1 benchmark scores, and Algebra 1 benchmark subscores. The goal was to determine if there was a significant difference in the two groups in order to inform if the rigorous preparation program should be continued in its current form.

Significance of the Study

This study was significant because it added to the knowledge base for eighth-grade Algebra 1. More specifically, it considered how students are prepared to meet the demands of eighth-grade Algebra 1, including how teachers use higher-order thinking questions and feedback. It determined if there was a significant difference in student achievement scores in eighth-grade Algebra 1 as measured by grades and benchmark scores. These results can contribute to how other teachers might prepare their students for eighth-grade Algebra 1 and what policies might be considered to help students meet the rigorous demands of taking Algebra 1 before high school, including policies which promote equitable access to eighth-grade Algebra 1.

Limitations of the Study

A limitation of this study was that there were other factors which may have influenced student achievement on grades and benchmarks, including how much support students received at home and the effectiveness of students' previous math teachers. Thus, the study only compared rather than correlated results. A delimitation of this study was that it was limited to one school system in Tennessee which only had one eighth-grade Algebra 1 class for the district. Thus, the sample was relatively small with a sample size of twenty-one students who participated in the study.

Definitions

- **critical thinking** - the process of analyzing and assessing thinking with a view to improving it (Elder & Paul, 2010)
- **eighth-grade Algebra 1** – Algebra 1 course offered to eighth-grade students who have been selected based on grades, assessment scores, and teacher recommendations. Students may earn high school credit for this course if they pass the end of course (EOC) test at the end of the year.
- **feedback** - information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding (Hattie & Timperly, 2007)
- **formative feedback** - information communicated to the learner that is intended to modify his or her thinking or behavior for the purpose of improving learning (Shute, 2008)
- **junior high school** – a school which has 6^{th}, 7^{th}, and 8^{th} grade students

- **rigorous preparation program** – a series of challenge questions which align with each unit taught in seventh-grade math. These question sets are characterized by higher-order thinking questions which challenge students to make generalizations, justify solutions, and problem solve in real-world situations. Students receive extensive teacher feedback based on their responses.
- **self-concept of ability** - how a student perceives their abilities in an academic area (McPartlan et al., 2021)

Overview of the Study

This thesis is composed of five chapters. Chapter 1 introduced background information pertaining to the study and provided the statement of the problem, purpose of the study, significance of the study, limitations, and definitions. Chapter 2 will provide an in-depth review of the literature concerning eighth-grade Algebra 1, rigorous math curriculum focused on critical thinking skills, and teacher feedback. Chapter 3 will describe the methods used in the study and list the research questions and hypotheses. Chapter 4 will present the findings of the study including data analyses. Finally, Chapter 5 will discuss the findings of the study, conclusions of the study, and recommendations for future research and practice.

Chapter 2

Introduction

One mark of an effective educator is a desire to continually improve their instructional practice (Bright, 2012). When teachers reflect on and work to improve their practices, they have a greater impact on student achievement and growth. At a specific Jr. high school in Tennessee, seventh-grade students are offered the opportunity to take Algebra 1 their eighth-grade year if they meet specific conditions. These conditions consider the student's seventh grade math grades, the student's scores on a series of four tests which compare their performance to other seventh grade students interested in the program, and teacher recommendation. Some seventh-grade students who are applying for eighth-grade Algebra 1 are given the additional requirement of completing a rigorous preparation program which includes a series of challenge questions which promote higher-order thinking skills. These students are given a set of challenge questions for each unit covered in seventh-grade math. They have the entire unit to complete the problems and are asked to submit them by the day of the unit test. While these questions are still related to the Tennessee seventh-grade math standards, they go above and beyond what students will see in class and challenge students to make mathematical generalizations and apply the principles they have learned to much more complex situations. After the students have submitted their challenge questions, they receive back extensive feedback related to their responses and are asked to review the comments in order to continue growing in their thinking. The challenge questions are ungraded and do not factor into a student's math grade. The purpose of this study was to identify if there was a difference between students' semester grades, benchmark scores, and benchmark subscores in eighth-grade Algebra 1 for students who participated in the rigorous seventh-grade preparation program and those who did not.

There are several research studies which investigate the benefits of eighth-grade Algebra 1 as well as limitations and concerns. This literature review first examines these dimensions of eighth-grade Algebra 1 programs. Two major areas are related to the nature of the seventh-grade rigorous preparation program: critical thinking and teacher feedback. Students in the seventh-grade rigorous preparation program are provided rigorous questions which require them to use and develop their higher-order thinking skills in order to apply, analyze, synthesize, and evaluate what they have learned during seventh-grade math. Thus, the importance of rigorous curriculum and effect of critical thinking on student learning and achievement developed as an area of exploration. The feedback process for these challenge questions is extensive. Students receive feedback on almost every question and are asked to review the feedback so they can continue to develop how they are thinking and approaching questions. Thus, teacher feedback was another important element to investigate since it is so essential to the rigorous preparation program. It was necessary to determine what is known about the benefits and concerns of eighth-grade Algebra 1 programs, rigorous curriculum and critical thinking skills, and effective teacher feedback since these are the major elements of the rigorous preparation program which could potentially be affecting student achievement in eighth-grade Algebra 1. This literature review explores these areas of interest.

Benefits and Concerns of Eighth-Grade Algebra 1

Algebra 1 has been described as the "gatekeeper to more advanced courses in both mathematics and science" (Spielhagen, 2006, p. 34). Many schools are offering Algebra 1 before high school and often in eighth grade in order to provide students with more opportunities for these higher-level courses in high school. Researchers have highlighted several benefits to offering Algebra 1 in eighth grade. One such study focused on a large southeastern school

district where eight-grade Algebra 1 was offered at all eleven of its middle schools (Spielhagen, 2006). The middle schools included were a mix of rural and urban and included some schools with diverse populations. Researchers compared the group who took eighth-grade Algebra 1 to those who did not. Additionally, they included a comparison between students of similar math achievement (as of the end of their seventh-grade year) who took eighth-grade Algebra 1 versus those who took Algebra 1 in ninth grade. More specifically, they looked at the number of math classes they took after eighth-grade math, math achievement scores, and college attendance. They found that the students who took eighth-grade Algebra 1 on average took a larger quantity of math courses in high school as well as higher-level courses (Spielhagen, 2006). These students also attended college at higher rates than the groups who did not take eighth-grade Algebra 1.

Lee and Mao (2021) expanded Spielhagen's (2006) research on eighth-grade Algebra 1. Lee and Mao (2021) used a national dataset from the High School Longitudinal Study of 2009 as opposed to Spielhagen's (2006) data from only one large school district. This dataset offered a much larger and representative sample of 15,390 students from across the United States. Lee and Mao (2021) examined how taking Algebra 1 before high school is associated with student math achievement and which math courses students take throughout high school. They found a positive significant relationship between taking Algebra 1 before high school and students' achievement scores and high school math courses. More specifically, students who had taken Algebra 1 before high school scored significantly higher on ninth- and eleventh-grade math achievement tests than students who did not take Algebra 1 until high school. Depending on the statistical model used, a student who took Algebra 1 before high school had a 14%-29% higher likelihood of taking Calculus or higher in high school than students who waited until high school to take Algebra 1 (Lee & Mao, 2021). Thus, Spielhagen (2006) and Lee and Mao (2021)

determined that taking Algebra 1 before high school can open doors for students. These students have better opportunities to take higher-level math courses in high school, take a larger quantity of math courses in high school, score higher on math achievement tests, and attend college at higher rates. All of these benefits are reasons why many school districts offer eighth-grade Algebra 1 programs to their students.

While there are many benefits to eighth-grade Algebra 1, this course is not always equally accessible to all students. Several factors affect whether a student will take Algebra 1 before high school. Filer and Chang (2008) used the National Education Longitudinal Study (NELS) dataset to determine if parent influence, peer influence, and socioeconomic status influence whether students take algebra in middle school. They determined that parent encouragement and peer encouragement both correlated with students taking eighth-grade Algebra 1, with parent encouragement having a slightly higher correlation. The data also indicated that low socioeconomic students were less likely to take eighth-grade Algebra 1, but socioeconomic status was not highly correlated with whether a student received parent or peer encouragement (Filer & Chang, 2008). Thus, even if a student has the prerequisite skills and knowledge to take eight-grade Algebra 1, lack of parent or peer encouragement or their socioeconomic status could influence whether they actually take Algebra 1 before high school and potentially reap the benefits of taking the course early.

Some researchers and school districts have recognized these inequities and focused on how to make eighth-grade Algebra 1 more equitably accessible to students who are prepared to take it before high school. Wake County Public School System (WCPSS) in North Carolina developed a policy for assigning students to math classes in middle school, including eighth-grade Algebra 1 (Dougherty et al., 2015). They used the Education Value-Added Assessment

System (EVAAS) measure to determine which students were eligible for accelerated math courses. The goal was to reduce bias in teacher recommendations for accelerated math courses and to promote equity in which students were given the opportunity to take these courses. Dougherty et al. (2015) pointed to underrepresentation of Black and Hispanic students as well as students from low socioeconomic backgrounds in accelerated math courses as being motivating factors for the study. These are groups which Filer and Chang (2008) highlighted in their earlier research. The WCPSS policy tried to strike a balance between the teacher or counselor recommendation system which may allow too much bias and the algebra-for-all movement which may force students who are not ready for algebra into algebra classes early (Dougherty et al., 2015). The policy attempted to make the selection process more objective by solely relying on EVAAS measures which help predict which students will have a high enough likelihood of achieving a Level III on the Algebra 1 EOC at the end of eighth grade. Dougherty et al. (2015) used a regression discontinuity to compare students just below and just above the cutoff for being recommended for the accelerated math courses. They found that the number of students taking accelerated math courses increased when the new policy was implemented (Dougherty et al., 2015). Generally, underrepresented populations were more proportionally represented in the accelerated math courses with the new policy than they previously were without the policy. However, there were still some discrepancies among Black and Hispanic students, even though the percentage of these students in accelerated math courses did increase. Other school systems have also adopted similar practices with the intention of creating equal access to eighth-grade Algebra 1. In a policy brief by the California Collaborative on District Reform, Bitter and O'Day (2010) suggest that school districts which are implementing eighth-grade Algebra 1 programs use additional data points beyond teacher recommendations and grades to determine if students

are prepared for eighth-grade Algebra 1. Like the WCPSS's policy, the goal of these additional data points, such as scores on state standardized tests or placement tests, is to improve greater equity and access to eighth-grade Algebra 1 (Bitter & O'Day, 2010). Both Dougherty et al. (2015) and Bitter and O'Day (2010) emphasize the importance of equitable access to eighth-grade Algebra 1 programs but also practical ways of making this course more accessible to students who are prepared to take it. It is important to note that the eighth-grade Algebra 1 program addressed in this study used a combination of teacher recommendation and student math grades as well as additional data points including placement tests and math TCAP scores when selecting students for the class.

While the literature does indicate that there are many benefits to taking Algebra 1 before high school and that school districts should make it a point to place as many eligible students as possible in eighth-grade Algebra 1, there are also studies which indicated that there are limitations to eighth-grade Algebra 1 programs, especially for students who do not have the prerequisite skills and knowledge to meet the demands of the course. Clotfelter et al. (2015) conducted a study which looked at two large North Carolina school districts which implemented early algebra programs for all students. When this policy was implemented, no changes were made to the previous math courses students took. They used a control group made up of four school districts which continued to offer eighth-grade Algebra 1 to students who met certain conditions rather than applying the algebra-for-all policy (Clotfelter, 2015). To determine how the eighth-grade Algebra 1-for-all policy affected student outcomes, they looked at EOC scores for Algebra 1, Geometry, and Algebra 2. They also used students' sixth- and seventh-grade math scores on state standardized tests to classify students based on their math performance before they entered an accelerated Algebra 1 course. Clotfelter et al. (2015) determined that when

students were accelerated to eighth-grade Algebra 1 but the curriculum for previous math courses were not reformed to meet the demands of taking Algebra 1 early, then this resulted in significantly lower performance in Algebra 1 and Geometry. Loveless (2008) also looked at the potential negative effects of pushing students to take eighth-grade Algebra 1 who do not have the required background skills and knowledge. Loveless (2008) discussed how there is a strong national push for more eighth-grade students to take Algebra 1. One reason behind this push is to provide greater equity and opportunities for students from low socioeconomic backgrounds and minority backgrounds and to help them to be more prepared for college. However, Loveless (2008) found that there was no correlation between the 2007 eighth-grade National Assessment of Educational Progress (NAEP) scores and advance enrollment in Algebra 1. This means that just because a state had a higher enrollment in Algebra 1 before high school does not necessarily mean that their students performed better in mathematics. Loveless (2008) argues that equity should still be a goal for selecting students for eighth-grade Algebra 1, but selection should be based on data, such as math achievement scores which indicate that a student has the background knowledge to be prepared to take the class. Thus, eighth-grade Algebra 1 can have negative effects for students who are not prepared to take the course. While equity is an important priority, unbiased data should be the foundation for selecting students to take eighth-grade Algebra 1.

Rigorous Curriculum and Critical Thinking Skills

As the previous section indicated, it is important for students to be prepared to take eighth-grade Algebra 1 in order to be successful and reap the potential benefits of taking the course before high school. Thus, it is important to examine how students become prepared for the demands of a course like eighth-grade Algebra 1. When reviewing the literature for this

study, rigorous curriculum appeared to be a logical starting point for preparing students for the demands of eighth-grade Algebra 1. Tyson and Roksa (2017) found that rigorous math courses are associated with a greater likelihood of taking higher math courses. They found that when students who have similar math achievement levels take different levels of the same course (Algebra 1 and Algebra 1 Honors, for example), then the student with the more rigorous course is more likely to take a higher-level math course in the future. In a policy brief by the California Collaborative on District Reform, Bitter and O'Day (2010) stress that it is not only important to discuss if Algebra 1 is offered in eighth grade but to examine mathematics curriculum across grade levels to see if it is rigorously preparing students for success with algebraic concepts and higher-level math courses. Bitter and O'Day (2010) emphasize that K-7 math classes should be steeped in algebraic thinking in order to help students build a strong foundation in algebraic thinking. However, they note that many teachers in these grade levels need extra support and preparation in order to help students build these foundations in early math classes. They suggest that K-7 math teachers should be offered extensive professional development which can help them gain the skills to effectively teach young students algebraic concepts. Steiner (2018) also emphasizes the importance of quality math curriculum on student achievement. Steiner (2018) indicates that quality math curriculum is often available at similar costs to lower-quality curriculum, and many free, open educational resources are available online. However, in order for math teachers to select a quality, rigorous curriculum, they must be able to identify what this quality curriculum looks like. Steiner (2018), like Bitter and O'Day (2010), points to professional development as a possible solution to this problem. Professional development which addresses how to evaluate the quality of curriculum, how to adapt curriculum to meet the needs of students, how to determine if curriculum aligns with standards, and how to effectively utilize

quality curriculum can help math teachers select curriculum which will better prepare students for future rigorous math courses such as Algebra 1. Gutiérrez (1996) found that there are factors within math departments which promote more students to take higher level math courses. These practices include a rigorous, common curriculum, a commitment to students, a commitment to collective enterprise, and innovative instructional strategies (Gutiérrez, 1996). This research indicates that while a rigorous curriculum is important, other factors including the culture of a math department also affect how math departments run and how students achieve in math. Barnett and Corazza (1993) conducted a study which examined how employing a rigorous, intensive math curriculum and individualizing instruction to student needs (specifically, high-achieving students) can help students rise to the challenge and master more advanced math concepts while also promoting self-esteem. Thus, a rigorous math curriculum which includes algebraic concepts and promotes a culture of high achievement for all students are some important factors when preparing students for the demands of eighth-grade Algebra 1.

One quality of a rigorous curriculum is a focus on helping students develop critical thinking skills. Elder and Paul (2010), define critical thinking as "the process of analyzing and assessing thinking with a view to improving it" (p. 38). In this definition, the thinker (the student in the case of this research) is active in the process. A forward motion of building on what one already knows and understands is indicated. Elder and Paul (2010) also indicate that as students develop critical thinking skills, they become better learners. Students who develop critical thinking skills are expanding their horizons on how they approach specific content and become more efficient in how to engage with what they are learning. Additionally, Elder and Paul (2010) note that critical thinking skills need to be developed over time with multiple opportunities to grow critical thinking skills. McCollister and Sayler (2010) similarly

suggest that critical thinking skills support academic achievement and help students better analyze what they are learning. They note that high-achieving students, especially gifted students, need rigorous learning environments which help stimulate their thinking and help them grow academically (McCollister & Sayler, 2010). Smith & Szymanski (2013) suggest that one way for students to develop their critical thinking skills is to provide them with more opportunities to engage in higher-order questions. This is important to note because the challenge questions which students in the rigorous preparation program are provided with are higher-order questions. The hope is that these questions would help students develop their critical thinking skills and in turn, become better learners so they can be more successful in the eighth-grade Algebra 1 program. It is also important to note that Elder and Paul (2010) indicate that development of critical thinking skills should be supported across disciplines.

The question then becomes what does critical thinking look like and how can it be implemented? Smith and Szymanski (2013) point to the Gallagher and Aschner classification model which categorizes questions in one of four categories "(1) cognitive-memory (low order convergent), (2) convergence (high order convergent), (3) divergence (low order divergent), and (4) evaluative (high order divergent)" where convergent questions lead to a single answer while divergent questions lead to multiple answers and more creative responses (pp. 20-21). These have some parallels with the often more familiar Bloom's taxonomy. The goal is for teachers to use divergence and evaluation type questions in order to help students dig deep into their thinking. Along the lines of more divergent questions, Elder and Paul (2010) state that in order to develop critical thinking skills, students should be provided opportunities to

> raise vital questions and problems, gather and assess relevant information, come to well-reasoned conclusions and solutions, think open-mindedly with alternative systems of

> thought, and communicate effectively with others in figuring out solutions to complex problems. (p. 38)

Jaffe (2020) notes that when students are given problems which allow them to take various problem-solving paths, such as problems which involve critical thinking skills, then they are provided with a rigorous learning opportunity which allows them to develop grit. When students develop grit, they are willing to persevere to achieve a challenging goal such as taking on more difficult math courses (Jaffe, 2020). These types of questions and critical thinking experiences are ones that students may not experience on a regular basis in the general education math classroom. One goal of the challenge questions provided to students in the rigorous preparation program is to provide them greater exposure to more challenging experiences than they might otherwise experience in seventh-grade math. Sometimes, teachers feel unprepared to effectively implement rigorous questions which promote critical thinking skills. Smith and Szymanski (2013) note that teachers are more likely to implement higher-order thinking in their classrooms when they are able to engage in professional development on higher-order thinking strategies and participate in professional learning communities which will support their implementation of these strategies. Just as students need support to help develop critical thinking skills, teachers need support in how to teach and implement these skills in their classrooms.

While researching, there seemed to emerge several side benefits, besides achievement, when students are exposed to rigorous curriculum which allows them the opportunity to develop critical thinking skills. Developing critical thinking skills helps students take ownership of what they are learning (Elder & Paul, 2010). Additionally, Smith and Szymanski (2013) found that higher-order thinking skills help students engage in a disciplinable manner, become better citizens, and become more marketable when looking for a job. Thus, the residual benefits of

higher-order thinking and critical thinking skills mean that students will likely be more motivated in their studies and more prepared to enter the real-world as an adult.

Effective Teacher Feedback and Its Effects

Teacher feedback emerged as an area to research in this study since the rigorous preparation program employed extensive teacher feedback. Once students submitted their challenge questions at the end of each unit, the teacher provided written feedback to help students extend their thinking both on correct and incorrect answers. Students were then asked to review the feedback in order to keep developing their critical thinking skills. Núñez et al. (2015) found that as students progressed in school (from middle school through high school), the perceived amount of feedback they received on homework decreased. This study also found that there was a significant association between teacher feedback on homework and amount of homework completed as well as amount of homework completed and academic achievement (Núñez et al., 2015). Thus, teacher feedback on homework appears to have an indirect relationship with student achievement. In a time when students start to receive less feedback traditionally, students who were part of the rigorous preparation program actually received an increased amount of feedback on their work engaging in higher-order problem solving. It was important to examine several facets of feedback including how teachers give effective feedback, how feedback influences a student's affect, and how feedback can influence student achievement.

Hattie and Timperley (2007) define feedback as "information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (p. 81). Brookhart (2008) writes extensively on how to provide quality, effective feedback to students. Written feedback is the primary source of feedback for students when it

comes to the challenge questions used in the rigorous preparation program. According to Brookhart (2008), when providing students with written feedback, three main factors should be considered – feedback clarity, specificity, and tone and word choice. First, feedback should be clear and matched to the student's level so they are more likely to understand and use the feedback provided (Brookhart, 2008). Second, written feedback should be specific enough so that the student has direction on what to do next but not so specific that the student is overwhelmed by suggestions or not able to utilize too broad of suggestions (Brookhart, 2008). Finally, the tone and word choice of written feedback should convey that the student is respected by the teacher and is an active participant in their learning (Brookhart, 2008). From a meta-analysis on various studies on feedback, Hattie and Timperley (2007) found that information feedback about a task has the highest effect size out of the various types of feedback analyzed. This is feedback which lets the student know how they can better perform a task. In fact, when students are provided with feedback on the process they used to complete a task, this can lead to deeper learning (Hattie & Timperley, 2007). Relatedly, Shute (2008) found that specific feedback which targets helping students improve their responses can greatly impact student learning. Shute (2008) also extensively reviewed literature on feedback and discovered that formative feedback should include a mixture of verification feedback (stating whether a response is right or wrong) and elaboration feedback (elaborating on a specific dimension of the response in order to provide the student with more specific feedback). Thus, the literature indicates that the contents of feedback as well as its focus can greatly affect the quality of the teacher feedback.

Interestingly, both Hattie and Timperley (2007) and Shute (2008) found that there can be some potential benefits when feedback is delayed. Hattie and Timperley (2007) found that delayed feedback has a strong effect size for difficult tasks, possibly because more processing is

involved in these types of tasks. Shute (2008) found that delayed feedback may help students transfer their learning to new situations and problems. Shute (2008) concluded that some of the benefits to delayed feedback include promoting active cognitive processing, more attention to metacognitive skills, and improved autonomy. The challenge questions provided to seventh-grade math students involved delayed feedback. Students worked on questions for several weeks and turned in their responses at the end of a unit then received feedback a few days after turning in their responses. A goal of the challenge questions was for students to be able to transfer their learning of seventh-grade math skills in order to become better problem solvers and to develop critical thinking skills. The literature seems to support the feedback timeline used with the challenge questions.

When teachers provide feedback to students, it is important to consider how they will receive this feedback. Wiliam (2012) states that students will respond to feedback in one of four ways: "he or she can change their behavior, modify their goal, abandon their goal, or reject the feedback" (p. 32). Students' reactions to feedback determine if the feedback is effective. Wiliam (2012) determines that teachers need to create classroom environments where students are focused on growth so that students are more willing to accept and use feedback. He suggests teachers can best do this by communicating to students that mistakes are an important part of the learning process and that how good a student is in a specific discipline is more dependent on effort rather than innate ability (Wiliam, 2012). McPartlan et al. (2021) considered how feedback can affect adolescents' math self-concept. Self-concept of ability is described as how a student perceives their abilities in an academic area (McPartlan et al., 2021). McPartlan et al. (2021) conducted a longitudinal study where they used rating scales to measure how students felt about their ability in math with follow-up questions about what helped inform them that they were

good at math (if they indicated that they thought they were good at math). They found that early adolescent students tend to focus on different feedback sources (parents, teachers, peers, their growth compared to other content areas, or their growth in a content over time) in order to improve their self-concept of ability. Thus, they determined it may be important for teachers to provide as many sources of feedback as possible to provide adolescent students the opportunity to build their belief in their math abilities. This research indicates that the written feedback approaches which Brookhart (2008) discusses should be part of variety of feedback options to employ, especially with middle school age students.

Researchers have conducted specific studies which have explored how feedback affects student achievement. Butler and Nisan (1986) designed a study where three groups were given various levels of feedback on tasks including task-related feedback, grades as feedback (norm-referenced), and no feedback. They found that students who received task-related feedback, which highlighted both something they did well and something they could improve, showed more improvement on tasks than students who only received grades or no feedback at all (Butler & Nisan, 1986). Additionally, they found that students who received task-related feedback showed a significantly higher level of interest in the tasks they were provided and attributed their success to internal factors such as effort (Butler & Nisan, 1986). Many of the elements of quality written feedback which Brookhart (2008) discusses are used by Baliram and Ellis (2019) in their research. These researchers performed a study that looked at the achievement of advanced geometry students who practiced reflective assessment and received content-specific teacher feedback compared to students who did not (Baliram & Ellis, 2019). They defined reflective assessment as assessment which is intended to help students learn and grow in a specific content area. The process they used not only used reflective assessment but also metacognition which

was not a factor inherent to the rigorous preparation program which was researched in this study. Baliram and Ellis (2019) used a nonequivalent control group design where one group received content-specific feedback over a four-week period on tasks they completed while the control group did not. They administered a pretest, posttest, and retention test to the students in both groups in order to compare the results of feedback both short and long term. The study determined that there was a statistically significant difference between the experimental and control group achievement scores as evidenced by statistical analysis of the pretest, posttest, and retention tests. This study is important because it not only compares achievement in the short term but compares the longer-lasting effects of reflective assessment, content-specific feedback, and metacognition on student learning. Since this study indicated that reflective assessment, content-specific feedback, and metacognitive practices had lasting effects on achievement, teachers should consider regularly using these practices. The practices used in Baliram and Ellis' study embody what Brookhart (2008) describes as "[lighting] the way forward" when providing students feedback on their work (p. 35). This means the teacher helps the student identify what is wrong and suggest how they can do something about it. This model still allows the student to be the problem solver, but it equips them to move forward in their learning.

Conclusion

Eighth-grade Algebra 1 has been praised for its potential benefits. The literature indicates that eighth-grade Algebra 1 can lead to students taking more math courses in high school, taking higher-level math courses in high school, and achieving higher levels as measured by math assessments (Lee & Mao, 2021; Spielhagen, 2006). However, students have to be prepared to meet the demands of eighth-grade Algebra 1 and may not be able to reap the benefits of taking Algebra 1 early unless they are prepared with the prerequisite skills and knowledge (Clotfelter et

al., 2015; Loveless, 2008). Students can be better prepared to meet the demands of Algebra 1, or any higher-level math course, by taking rigorous math courses which employ the use of quality curriculum (Bitter & O'Day, 2010; Steiner, 2018; Tyson & Roksa, 2017). These courses should be steeped in critical thinking skills which allow students the opportunity to improve their problem-solving skills and become better learners (Elder & Paul, 2010; McCollister & Sayler, 2010). Finally, students need to receive effective teacher feedback which helps them understand how they did with a task as well as their process towards approaching a task (Hattie & Timperley, 2007; Shute, 2008). When students receive quality feedback, there is evidence that their achievement will increase (Baliram & Ellis, 2019; Butler & Nisan, 1986). The benefits and concerns of eighth-grade Algebra 1 programs, rigorous curriculum and critical thinking skills, and effective teacher feedback and its effect on students are all essential to understanding the backdrop for how a rigorous preparation program for eight-grade Algebra 1 may produce different results when comparing students' semester grades, benchmark scores, and benchmark subscores in eight-grade Algebra 1. This literature review addressed these areas and sets the stage for this study's research questions and resulting data.

Chapter 3

Introduction

The purpose of this study was to compare students who participated in a rigorous seventh-grade Algebra 1 preparation program to those who did not participate at a selected junior high school in Tennessee. This comparison included several measures of achievement including semester 1 eighth-grade Algebra 1 grades, Algebra 1 benchmark 1 scores (administered in late September), Algebra 1 benchmark 2 scores (administered in December), and subscores on Algebra 1 benchmarks 1 and 2. The goal was to determine if there was a significant difference in the two groups in order to inform if the rigorous preparation program should be continued in its current form. This chapter describes the population, sampling procedures and participants, data collection procedures and instruments, procedures, and research questions and hypotheses used in this research study.

Population

The research was conducted at a junior high school in Northeast Tennessee. The junior high school was the only one in the district. The district was a city school district. The school had a population of 631 students. Of those students, 92.2% were white, 5.2% were black or African American, 1.9% were Asian, and 0.6% were American Indian. The percent of students who qualified for free or reduced-price lunch was 44% . The school population was 48.3% male and 51.7% female. Out of the population, 17.4% of students received special education services, including gifted students.

Sampling Procedures and Participants

The sample used in the study was the only eighth-grade Algebra 1 class offered at the selected junior high school. Selection for eight-grade Algebra 1 at this school was based on students' grades in seventh-grade math, teacher recommendations, and students' scores on a series of math tests which compared their performance to other seventh-grade students who were also applying for eighth-grade Algebra 1. This sample was selected by the researcher because it was from the school where she taught, and it was a class where some of the students experienced a rigorous preparation program during their seventh-grade math class while other students in the class did not. This class had 21 students. Out of the students in the eighth-grade Algebra 1 class, 95.2% were white and 4.8% were Asian, 47.6% were male and 52.4% were female, and 19% received gifted services. Out of the students in the sample, 10 participated in the rigorous preparation program in math their seventh-grade year while the other 11 did not. The 10 who participated completed sets of rigorous challenge questions for each seventh-grade math unit and then received extensive feedback on their responses.

Data Collection Procedures and Instruments

The data used in this study included semester 1 eighth-grade Algebra 1 grades and scores from two benchmark assessments. Semester 1 grades were an average of students' first and second nine weeks grades from eighth-grade Algebra 1. Grades were determined based on student performance on homework assignments, quizzes, and tests in eighth-grade Algebra 1. Grades were aligned with learning targets based on Tennessee Algebra 1 standards. Two benchmark assessments were administered during the first semester of the 2021-2022 school year. Benchmark 1 was administered at the end of September, and Benchmark 2 was administered in December. Both benchmark assessments were administered through the Mastery

Connect online testing platform. Test items were aligned with Tennessee Algebra 1 standards and pacing guides for the Comprehensive Educational Resources (CER) consortium in which the school district was a member. Test items originated from the CASE item bank and Certica item bank which included items which were tested for validity and reliability. Each benchmark consisted of about 30 questions each and were each administered in class with the eighth-grade Algebra 1 teacher proctoring the assessments. For Benchmark 1, several standards were assessed which can be grouped into three main topics: quantities, expressions and equations, and linear functions. For Benchmark 2, the main topics included modeling linear functions and quadratic and polynomial functions. Semester 1 grades, Benchmark 1, and Benchmark 2 scores were all stored electronically. All grades and benchmark scores were exported into electronic spreadsheets at the end of the first semester and stored electronically for data analysis.

Procedures

The researcher first sought approval from the Milligan University Institutional Review Board (IRB). Once the Milligan University IRB granted approval for the research study, the researcher sought approval from the school board for the school associated with the study. Once approval was grated from both Milligan University IRB and the school board, the researcher selected the sample that would be used for the study, the only eighth-grade Algebra 1 class at the selected junior high school within the selected school district. Students in the sample were informed about the study, and informed consent forms were sent home with students so parents could indicate whether their child could participate in the study. After students returned their informed consent forms, the researcher collected data at the end of the first semester of the 2021-2022 school year. These data included semester 1 grades in eighth-grade Algebra 1 and Benchmark 1 and 2 scores in eighth-grade Algebra 1. Both grades and benchmark scores were

stored in electronic spreadsheets, and students were coded as either participating in the rigorous preparation program their seventh-grade year or not participating. These data are analyzed in Chapter 4.

Research Questions and Hypotheses

RQ1. Is there a significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

RQ2. Is there a significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior. high school in Tennessee.

RQ3. Is there a significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

RQ4. Is there a significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1

preparation program and those who did not participate at a selected junior high school in Tennessee.

RQ5. Is there a significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

RQ6. Is there a significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1

preparation program and those who did not participate at a selected junior high school in Tennessee.

RQ7. Is there a significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

Chapter 4

Introduction

The purpose of this study was to compare students who participated in a rigorous seventh-grade Algebra 1 preparation program to those who did not participate at a selected junior high school in Tennessee. This comparison included several measures of achievement including semester 1 eighth-grade Algebra 1 grades, Algebra 1 benchmark scores, and Algebra 1 benchmark subscores. The goal was to determine if there was a significant difference in the two groups in order to inform if the rigorous preparation program should be continued in its current form.

Data Collection

The two groups, those who participated in a rigorous seventh-grade Algebra 1 preparation program and those who did not, participated in eighth-grade Algebra 1 as usual and received grades and took regularly-scheduled benchmark tests during the first semester of the 2021-2022 school year. At the end of the semester, the eighth-grade Algebra 1 teacher assigned students a semester 1 grade based on the average of their first- and second-nine weeks grades for Algebra 1. These grades were based on assignment, quiz, and test grades in the class. These grades were pulled at the end of the semester for the purpose of this study. Students were also administered two CASE 21 common benchmark assessments which were used by the school district and other school districts in the area who participated in the Comprehensive Educational Resources (CER) consortium. Benchmark 1 was administered in September and Benchmark 2 was administered in December. These two benchmarks included about thirty questions each, and the questions aligned with Algebra 1 standards covering quantities, expressions and equations,

linear functions, modeling linear functions, and quadratic and polynomial functions. The benchmark tests utilized a variety of question types including multiple choice, multiple select, and free response items. At the end of the semester, benchmark scores were exported from the Mastery Connect platform where the benchmarks were administered. Students' Benchmark 1 and Benchmark 2 scores were averaged to show their average performance on both benchmarks. Also, the percent correct for each of the five subtopics was calculated based on individual student responses for each topic.

Research Questions and Related Hypotheses

Seven research questions and related hypotheses were used to guide the analysis of data. All data were analyzed using IBM SPSS Statistics (Version 28) with $p = .05$ as the level of significance.

RQ1. Is there a significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' semester one grades in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 1, an independent-samples t-test comparing the mean Semester 1 grades for 8th grade Algebra 1 of students who participated in a rigorous preparation

program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were assumed equal (p = .491). No significant difference between the means of the two groups ($t(16) = .181$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program (M = 97.313, SD = 5.1682) was not significantly different from the mean for the students who did not participate in the rigorous preparation program (M = 96.900, SD = 4.5019). The results are displayed in Table 1.

Table 1

Independent-Samples t-test on Semester 1 Grades for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	97.313	5.1682	16	.181	.859
Not a participant	96.900	4.5019			

Note. p > .05

RQ2. Is there a significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior. high school in Tennessee.

To answer research question 2, an independent-samples t-test comparing the mean benchmark scores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were not assumed equal ($p = .014$). No significant difference between the means of the two groups ($t(12.642) = -.235$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 70.50$, $SD = 5.127$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 71.50$, $SD = 12.159$). The results are displayed in Table 2.

Table 2

Independent-Samples t-test on Benchmark Scores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	70.50	5.127	12.642	-.235	.818
Not a participant	71.50	12.159			

Note. p > .05

RQ3. Is there a significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 3, an independent-samples t-test comparing the mean benchmark quantities subscores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were assumed equal ($p = .141$). No significant difference between the means of the two groups ($t(16) = -.239$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 72.88$, $SD = 23.479$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 75.00$, $SD = 13.992$). The results are displayed in Table 3.

Table 3

Independent-Samples t-test on Benchmark Quantities Subscores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	72.88	23.479	16	-.239	.814
Not a participant	75.00	13.992			

Note. $p > .05$

RQ4. Is there a significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 4, an independent-samples t-test comparing the mean benchmark expressions and equations subscores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were not assumed equal ($p = .009$). No significant difference between the means of the two groups ($t(13.201) = 1.147$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 85.63$, $SD = 6.232$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 80.10$, $SD = 13.552$). The results are displayed in Table 4.

Table 4

Independent-Samples t-test on Benchmark Expressions and Equations Subscores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	85.63	6.232	13.201	1.147	.272
Not a participant	80.10	13.552			

Note. p > .05

RQ5. Is there a significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 5, an independent-samples t-test comparing the mean benchmark linear functions subscores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were assumed equal ($p = .559$). No significant difference between the means of the two groups ($t(16) = 1.084$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 66.88$, $SD = 13.217$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 60.80$, $SD = 10.602$). The results are displayed in Table 5.

Table 5

Independent-Samples t-test on Benchmark Linear Functions Subscores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	66.88	13.217	16	1.084	.295
Not a participant	60.80	10.602			

Note. p > .05

RQ6. Is there a significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 6, an independent-samples t-test comparing the mean benchmark modeling linear functions subscores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were assumed equal ($p = .970$). No significant difference between the means of the two groups ($t(16) = -.616$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 71.38$, $SD = 13.426$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 75.60$, $SD = 15.233$). The results are displayed in Table 6.

Table 6

Independent-Samples t-test on Benchmark Modeling Linear Functions Subscores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	71.38	13.426	16	-.616	.547
Not a participant	75.60	15.233			

Note. $p > .05$

RQ7. Is there a significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?

H_a. There is a significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

H_0. There is no significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee.

To answer research question 7, an independent-samples t-test comparing the mean benchmark quadratic and polynomial functions subscores for 8th grade Algebra 1 of students who participated in a rigorous preparation program and those who did not participate at a selected junior high school in Tennessee was conducted. Levene's test for equality of variance indicated that variances were not assumed equal ($p = .031$). No significant difference between the means of the two groups ($t(13.046) = -1.384$, $p > .05$) was found. The mean for the students who participated in the rigorous preparation program ($M = 62.50$, $SD = 7.982$) was not significantly different from the mean for the students who did not participate in the rigorous preparation program ($M = 71.20$, $SD = 17.769$). The results are displayed in Table 7.

Table 7

Independent-Samples t-test on Benchmark Quadratic and Polynomial Functions Subscores for 8th Grade Algebra 1

Rigorous preparation program	*M*	*SD*	*df*	*t*	*p*
Participant	62.50	7.982	13.046	-1.384	.190
Not a participant	71.20	17.769			

Note. p > .05

Conclusion

This chapter covered the purpose of the study, what data instruments were used, how data were collected, and how data were analyzed. Then, each research question and hypothesis was addressed by using a series of independent t-tests. The results were described and analyzed, and statistical measures were organized in tables.

Chapter 5

Summary of Findings

This chapter begins with a summary of findings, then discusses the results of the study, then draws conclusions, and finally addresses recommendations both for future research and for practice. The purpose of this study was to compare students who participated in a rigorous seventh-grade Algebra 1 preparation program to those who did not participate at a selected junior high school in Tennessee. This comparison included several measures of achievement including semester 1 eighth-grade Algebra 1 grades, Algebra 1 benchmark scores, and Algebra 1 benchmark subscores. This thesis addressed seven research questions which focused on determining if there was a difference in the two groups' various achievement measures. For all seven research questions, the data analysis indicated that there were no significant differences in the two groups' semester 1 grades, benchmark scores, or benchmark subscores (for quantities, expressions and equations, linear functions, modeling linear functions, and quadratic and polynomial functions), and the null hypotheses were supported for each research question. The results indicated that the rigorous preparation program made no significant difference among the two groups of students which indicates that the rigorous preparation program should not continue in its current form.

Discussion of Findings

Regarding research question 1, (Is there a significant difference between students' semester one grades in 8^{th} grade Algebra 1 for those who participated in a rigorous 7^{th} grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(16) = .181$, $p > .05$) between the semester 1 eighth-grade Algebra 1 grades for the two groups of

students, and the null hypothesis was retained. Regarding research question 2 (Is there a significant difference between students' benchmark scores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(12.642) = -.235$, $p > .05$) between the benchmark scores for the two groups of students, and the null hypothesis was retained. Regarding research question 3 (Is there a significant difference between students' benchmark quantities subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(16) = -.239$, $p > .05$) between the benchmark quantities subscores for the two groups of students, and the null hypothesis was retained. Regarding research question 4 (Is there a significant difference between students' benchmark expressions and equations subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(13.201) = 1.147$, $p > .05$) between the benchmark expressions and equations subscores for the two groups of students, and the null hypothesis was retained. Regarding research question 5 (Is there a significant difference between students' benchmark linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(16) = 1.084$, $p > .05$) between the benchmark linear functions subscores for the two groups of students, and the null hypothesis was retained. Regarding research question 6 (Is there a

significant difference between students' benchmark modeling linear functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(16) = -.616$, $p > .05$) between the benchmark modeling linear functions subscores for the two groups of students, and the null hypothesis was retained. Regarding research question 7 (Is there a significant difference between students' benchmark quadratic and polynomial functions subscores in 8th grade Algebra 1 for those who participated in a rigorous 7th grade Algebra 1 preparation program and those who did not participate at a selected junior high school in Tennessee?), an independent t-test indicated that there was no significant difference ($t(13.046) = -1.384$, $p > .05$) between the benchmark quadratic and polynomial functions subscores for the two groups of students, and the null hypothesis was retained.

The data analyses were inconsistent with the findings of the literature review. Two important elements of the rigorous preparation program examined in this study were the use of rigorous, higher-order thinking questions which employed critical thinking skills and feedback. Elder and Paul (2010), indicated that critical thinking involves "the process of analyzing and assessing thinking with a view to improving it" and that as students develop critical thinking skills over time, they become better learners (p. 38). Smith and Szymanski (2013) found that increasing the number of higher-order questions results in the development of critical thinking skills. Steiner (2018) supported that quality math curriculum, which includes higher-order thinking opportunities for students, can have a significant impact on student achievement. Additionally, McCollister and Sayler (2010) stated that critical thinking supports academic

achievement and that high-achieving students, especially gifted students, need rigorous learning environments which help stimulate their thinking and help them grow academically.

The rigorous preparation program provided students feedback on their responses to higher-order thinking questions intended to develop critical thinking skills. In the literature review, Hattie and Timperley (2007) propose that effective feedback informs students about their goals, how they are progressing toward their goals, and what steps they need to take to keep moving forward. Additionally, they found that when students are provided with feedback that focuses on the process of a task, that feedback can lead to deeper learning (Hattie & Timperley, 2007). Brookhart (2008) noted that when providing students with written feedback, three main factors should be considered – feedback clarity, specificity, and tone and word choice. Brookhart (2008) also noted that written feedback should "light the way forward" for students, meaning that teachers should help students identify what went wrong and suggest how students can do something about it (p. 35).

Even though the literature review indicated that using higher-order thinking questions which promote critical thinking skills and teacher feedback are both practices which can help improve student achievement, that was not the result of this study. One possible explanation for this is that students were not invested in the higher-order thinking questions and did not view them as a valuable learning opportunity with which to engage. Also, this specific group of eighth-grade Algebra 1 students participated in the rigorous preparation program during the 2020-2021 school year which was impacted by the COVID-19 pandemic. They went to school on a hybrid schedule most of the year and completed all assignments, including challenge questions (the higher-order thinking question sets), using an electronic format. They also received written feedback to their challenge questions using comments embedded in an

electronic program. Because of the electronic format, students may not have been aware of receiving feedback like they would be when receiving written feedback on paper. Thus, students may not have read the feedback or engaged in reflecting on their problem solving as was intended.

Conclusions

Since no significant difference was found between the group who participated in a rigorous preparation program before taking eighth-grade Algebra 1 and those who did not participate before taking eighth-grade Algebra 1, it can be concluded that the rigorous preparation program was not effective, at least in how it was implemented with this particular group of students. This group participated in the rigorous preparation program during the COVID-19 pandemic. As a result, these students attended school on a hybrid schedule for most of the school year (meaning half of their school days they learned in-person and the other half they learned virtually), and they completed challenge questions and received teacher feedback electronically. Since using higher-order thinking questions and providing students with quality teacher feedback have been shown to be effective strategies, it is reasonable to conclude that the instructional setting during the COVID-19 pandemic and the electronic format for completing assignments and receiving feedback could be what limited the impact of these strategies. If the challenge questions continue to be used as a way to provide students with rigorous preparation for eighth-grade Algebra 1, teachers need to consider discussing with students the importance of developing higher-order thinking skills and how those questions could aid in that development. This could help students be more aware of why they are completing the challenge questions and make them more invested in the process. Additionally, teachers may need to teach students how to receive and use written feedback so that the feedback has a greater impact on student learning.

Recommendations

Recommendations for Further Study

- The study should be repeated with teachers focusing on helping students see the value of higher-order thinking questions in developing their mathematical understanding. This could help students be more invested in the challenge questions and potentially impact their achievement.
- The study should be repeated with teachers focusing on helping students understand how to receive and use written feedback so that students can more effectively use the feedback to improve their mathematical understanding.
- The study should be repeated but use a different format for the rigorous preparation program (i.e., in-person learning and using paper and pencil rather than an electronic format). A different format for the preparation program might result in data that is more consistent with the literature review.

Recommendations for Practice

- Teachers should use higher-order thinking questions which promote critical thinking skills, making sure the questions are relevant to students.
- Teachers should provide feedback in a way that students will be able to use and reflect on in order to improve their learning.
- Preparation programs for advanced math classes must be examined for their benefits and shortcomings in order to improve the effectiveness of these types of programs.

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Date: November 28 2021

Principal Investigator: **Lindsey Kyker**, Graduate Student, Milligan University
From: The Institutional Review Board (IRB) at Milligan University
Project: *A Comparative Study of Students' Scores in Eighth-grade Algebra 1 for Students Who Participated in a Seventh-grade Rigorous Preparation Program and Those Who Did Not Participate at a Selected Junior High School in Tennessee*
IRB Tracking Number: **2021-13**
IRB Approval Number: **Exp2111282008**
Subject: **Final Approval**

On behalf of the Milligan University Institutional Review Board (IRB), we are writing to inform you that the above-mentioned study has been approved as expedited. This approval also indicates that you have fulfilled the IRB requirements for Milligan University.

All research must be conducted in accordance with this approved submission, meaning that you will follow the research plan you have outlined here, use approved materials, and follow university policies.

Take special note of the following important aspects of your approval:

- Any changes made to your study require approval from the IRB Committee before they can be implemented as part of your study. Contact the IRB Committee at **IRB@milligan.edu** with your questions and/or proposed modifications;
- If there are any unanticipated problems or complaints from participants during your data collection, you must notify the Milligan University IRB Office within 24 hours of the data collection problem or complaint;
- Milligan University requires specific formatting when collecting demographic data on gender; please contact me if you need assistance with this formatting.

The Milligan University IRB Committee is pleased to congratulate you on the approval of your research proposal. Best wishes as you conduct your research! If you have any questions about your IRB Approval, please contact the IRB Office and copy your faculty advisor if appropriate on the communication.

On behalf of the IRB Committee,

Trini Rangel, Ph.D.
Chair, Institutional Review Board
Milligan University