PATHWAYS TO AP MATHEMATICS

IN AN URBAN SCHOOL DISTRICT

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THE PATHWAY TO AP MATHEMATICS:

A QUANTITATIVE STUDY IN AN URBAN OPEN ENROLLMENT DISTRICT

Abstract

This study was used to examine the results of secondary school students who followed one of two pathways to enrollment in Advanced Placement (AP) mathematics courses. Students completed algebra 1 in either the eighth grade (pathway 1) or ninth grade (pathway 2). The study took place in an urban district that uses an open enrollment process for entry to AP courses. Three types of mathematics achievement scores were collected from 131 students enrolled in AP mathematics courses. A chi-square test revealed that students who completed algebra 1 in the eighth grade had significantly higher AP scores than their peers. A 2x2 MANOVA provided comparative information for students based on gender and pathway type with respect to two standardized mathematics assessments. Students who completed algebra 1 in the eighth grade had significantly higher scores on both assessments as compared to their peers who completed algebra 1 in the ninth grade.

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Dedications

To my husband, Phillip Saunders, for his unwavering love and support.

To my parents, Pam and Greg, for their endless encouragement and caretaking of our children.

To my children, Gloria and Gabriel, so that they may always have the persistence to follow through even when things are hard, take longer than they expect, and must balance other obstacles along the way.

TABLE OF CONTENTS

APPENDICES

TABLES

FIGURES

CHAPTER 1: INTRODUCTION TO THE STUDY

The purpose of this study was to examine the results of secondary school students following one of two pathways to enrollment in Advanced Placement (AP) mathematics courses. In one pathway, students completed algebra 1 in the eighth grade and in the other pathway, students completed algebra 1 in the ninth grade. The latter was the traditional course sequence. To enter algebra 1 in the eighth grade, students needed to complete an accelerated class in seventh grade. The accelerated curriculum combined the content of the seventh and eighth grade mathematics sequence into a 1-year course. This course was similar to what a pre-algebra course would have consisted of in the past, however, the district no longer offered a course titled pre-algebra. To enter this pathway, a student needed to demonstrate their readiness for abstract content through their grade 6 mathematics grades, a mathematical assessment score, and a teacher recommendation.

Pathway 1 included students who completed the accelerated course in seventh grade and algebra 1 in eighth grade. This sequence allowed them to complete high school mathematics courses that easily provided the opportunity to register for an AP course in grade 11 and/or 12. The only acceleration component for Pathway 1 students occurred in grade 7. Pathway 2 included students who were not in the accelerated course in the seventh grade, and therefore followed a traditional sequence of the Math 7 course, Math 8 course, algebra 1 in the ninth grade, and a typical mathematics sequence in grades 10 through 12.

All the participants in the study were students who were enrolled in AP classes in grades 11 or 12. Students in both pathways were able to enroll in AP statistics if they first completed algebra 1, geometry, and algebra 2. Pre-calculus was the prerequisite to enroll in AP calculus. To complete the prerequisites for AP calculus enrollment, Pathway 2 students needed to register

for two courses simultaneously, such as geometry and algebra 2 in grade 10. Any student could register for an AP mathematics course provided they completed the required course sequence. No teacher recommendations or other mathematics scores were required. In this district, this procedure was referred to as "Open Enrollment" for AP courses. Students who were in Pathway 1 had an advantage over those in Pathway 2 because they entered high school already having completed algebra 1.

Mathematics specialists disagree about when students should complete algebra 1 (Loveless, 2021; Weller, 2014). Algebra 1 is traditionally offered in grade 9, however, some researchers believe that it should be offered in grade 8 (Liang, Heckman, & Abedi, 2018). By offering algebra at an earlier grade level, students would have more options for completing a mathematics sequence of courses in high school, allowing them to easily register for an AP mathematics course in grade 11 or 12 without needing to take two courses simultaneously prior to AP enrollment (Daro & SERP Institute, 2014). The trajectory where algebra 1 is offered in the eighth grade, after a condensed and consolidated seventh grade year, works for the students who are developmentally ready in middle school to complete a challenging mathematics course offered at a quicker pace. Other students need options after grade 9 to complete the prerequisites to enroll in an AP mathematics course, such as doubling up on mathematics classes in grade 10 or 11. Creating a pathway to AP mathematics at the middle school and extending through high school can be based on educational policies at the school, district, and/or state levels (Colangelo, Assouline, & Gross, 2004, Vol. 2). In some districts, the pathway to an AP course is dependent on the earlier course outcomes and teacher recommendations, but in other schools, students themselves can choose to enroll in an AP course, if they have the prerequisites, and whether a teacher recommends them for it or not.

Regardless of which pathway a district follows, entry to an AP mathematics course requires the completion, and hopefully mastery, of a sequences of past mathematics skills and courses. Algebra 1 is considered a gateway to this sequence in the middle and high school level. If a student completes algebra 1 in grade 9, geometry in grade 10, algebra 2 in grade 11, and pre-calculus in grade 12, when can they complete an AP mathematics course? Some mathematics specialists have suggested that algebra 1 be completed at an earlier grade level by only targeted groups of students, who are deemed cognitively and developmentally ready, while others recommend all students should be exposed to algebra in eighth grade. Many states have adopted the Common Core State Standards (CCSS; corestandards.org). With the shift to these standards, many of the topics typically found in a high school algebra class are now found in middle school mathematics courses. There is no longer a course called pre-algebra in CCSS curricula, but typical pre-algebra content is now found in sixth, seventh, and mostly eighth grade. An accelerated class in seventh grade that combines seventh and eighth grade standards, now includes more topics than it did prior to CCSS adoption. Grades 6 and 7 include many topics that were traditionally found in grade 8 prior to the CCSS, and grade 8 standards heavily mimic a foundational level algebra 1 class.

There are three main pathway options that have been used by school district personnel to help students achieve mastery of mathematical skills, particularly so that they can enroll in an AP course. The following options are commonly used: (a) only students who qualify to be accelerated in mathematics based on specific criteria are enrolled in algebra 1 in grade 7 or 8 (Kriegler & Lee, 2006); (b) no one is accelerated in middle school, students are required to build a stronger mathematical foundation in grades 6-8 and, once students reach high school, they are provided with acceleration pathways to reach AP courses (Sawchuk, 2018); and (c) all students

in middle school are accelerated by taking algebra 1 in grade 8 (Burris, Heubert, & Levin, 2004; Liang, et al., 2018). This study is based on a school district that employed option "a" to assist students in gaining the experience to enroll in AP statistics or calculus courses. The purpose of this study was to find out if there was any difference in performance between students who were in Pathway 1or Pathway 2.

Rationale for Selecting the Topic

The purpose of this study was to compare the mathematics achievement of students who completed an AP mathematics course where approximately half of the students were accelerated in their middle school mathematics curriculum (Pathway 1), and half were not accelerated in middle school (Pathway 2). The Pathway 1 students completed two years of their mathematics curriculum in grade 7 by taking an accelerated class that combined and consolidated standards from both seventh and eighth grades, and then completed algebra 1 in eighth grade. The Pathway 2 students did not take the accelerated course in seventh grade. The study took place in an urban school district with fewer than 100,000 residents, where any student could choose to enroll in an AP course, if they completed the prerequisites. This is referred to as an open-enrollment policy. This study was designed to examine how following the different pathways affected overall student success. Student success was measured by AP, Scholastic Aptitude Test (SAT), and Standardized Testing and Reporting (STAR) mathematics achievement scores. By studying these students' pathways and outcomes, middle school mathematics leaders and teachers could use the results to determine whether to provide all, some, or none of the students with early placement in algebra 1 at the middle school level.

With the adoption of CCSS, many states struggle to teach all the recommended standards for a grade level within a single school year. This is even more challenging when district leaders

consider consolidating standards to combine two years of mathematics into one, in preparation for students to take the next grade level of mathematics (Colangelo, et al., 2004, Vol. 2). Some school district leaders have recently decided to forego an advanced track in middle school mathematics because there are more standards in middle school than there were prior to the CCSS adoption. This is of particular interest to middle school instructional leaders who are required to determine placement for students in their mathematics courses, as they prepare for the high school mathematics sequence.

There continue to be critics on both sides of the algebra 1 placement issue. Those who favor algebra 1 in grade 8 include advocates for gifted children (Weller, 2014). This is particularly true regarding schools without a comprehensive gifted program, where individual teachers might or might not be differentiating the curriculum for their students who demonstrate high potential (Weller, 2014). Those who believe students should wait until grade 9 before completing algebra 1 support the notion that it is best to present advanced content when a student is more mature (Chou, 2018, November 9; Kaplinsky, 2017, September 5). There is also a debate regarding the criteria to accept students in AP classes. President G. W. Bush supported an agenda to increase access to AP classes (Walters, 2006) for the U.S. to remain a competitive nation. This was met with party line controversy with some senators supporting the increased access and others fearing that the push to accept more students in AP courses would create more disparities in achievement (Walters, 2006). The National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) have urged high school leaders to reconsider the importance of offering AP Calculus in high school. Instead, they recommend that school districts ensure that students gain a strong mathematical foundation to be prepared for calculus in their post-secondary schooling (Daro & SERP Institute, 2014).

Course placement decisions are related to content knowledge, developmental readiness and social emotional factors. During the secondary school years, both middle and high school, students are figuring out who they are as people as well as how they fit in with their peers (Erikson, 1968). For example, some adolescents, while highly qualified for advanced mathematics, are not ready to face the stigma that can be associated with being in an advanced class (Ford & Whiting, 2010). Students need to be developmentally ready to put in the effort that an accelerated or AP class requires (Manzo, 2004; Yoder, 2025). School leaders convey a particular philosophical stance when they decide to accelerate only select middle school students, to accelerate no students, or to accelerate all students. This decision needs to be aligned with the district's vision for building the success of all students. Options for course pathways need to be aligned with the vision and mission of the district or they can be detrimental to students' success (Liang, Heckman, & Abedi, 2012).

This research focused on students who took AP courses in grade 11 or 12. AP, SAT, and STAR mathematics assessments were used to determine if any differences in student outcomes existed between those students in different pathways, those who started with an accelerated class in middle school and those who did not. It is vital for district leaders to know the performance results of students who are being placed in each pathway.

Statement of the Problem

Many studies speak to the importance of access to algebra topics in eighth grade (Spielhagen, 2006a), however a majority of the studies took place in the pre-CCSS era. Current decisions about when to take algebra should be based on the standards being used. For example, with the adoption of CCSS in most of the United States, an overwhelming number of algebra-based topics that were traditionally taught in high school algebra have been shifted into middle

school courses, mostly in the eighth-grade curriculum, with some topics appearing as early as sixth grade (Daro & SERP, 2014). Under CCSS, algebra is far more rigorous. It is unclear if algebra should be offered in the grade 8 at the expense of other mathematical concepts being skipped or consolidated at earlier grade levels (Warner, 2023).

While a variety of placement criteria and acceleration methods in mathematics exists, district personnel are not in agreement about the best pathway for students to complete high level mathematics courses between middle school and high school (Colangelo, et al., 2004, Vol. 2). Even within the same school district, there are inconsistencies with placement criteria (Spielhagen, 2006a), which creates a problem for placement equity and consistency in accelerated courses. This study includes an analysis of student performance for those students enrolled in AP mathematics courses during the 2018-2019 school year, focusing on their pathways prior to enrollment in an AP mathematics course and their overall success in the course as measured by standardized test scores. The results provide support for secondary school mathematics leaders trying to determine the most appropriate criteria for making recommendations for the placement of students into algebra 1. In general, research is available describing the impact of AP courses and their relationships to college success, but very little research exists regarding pathways to reach placement into AP courses, with few studies taking place after 2010, when CCSS was first implemented.

Potential Benefits of Research and Significance of the Study

The implications of this research will be specifically important to the district leaders who want information about the most appropriate time to offer algebra 1. The study provides a starting point for similar districts to review their paths for students which would result in completing AP courses.

Through the quantitative review of the assessment results related to the course pathways middle school leaders stand to benefit by receiving added knowledge that may help inform decision making about course sequencing.

Definition of Key Terms

The following terms were used for the purpose of this research study:

1. **Acceleration** is a widely used term, but for this study it refers to the telescoping method of acceleration where students take a class or classes in less time than normal, with a result of taking courses earlier in their mathematics careers than their peers (Colangelo, et al., 2004, Vol. 2).
2. **Achievement** means student proficiency results on standardized assessments ("What is Academic Achievement," no date).
3. **Open Enrollment** refers to students having the choice to take AP courses or lower-level courses, based on having the prerequisites, their preferences, and comfort level rather than teacher recommendation and past performance (Aguilar, Morocco, Parker, & Zigmond, 2006).
4. **Student Achievement** refers to overall scores on the AP Mathematics exam (Calculus or Statistics), STAR mathematics assessment, and the mathematics section of the SAT.
5. **STAR** is a diagnostic assessment, including a mathematics portion, given multiple times a year. It consists of 24 problems and is typically administered in 30 minutes (Renaissance Learning, 2016).

6. **SAT** is a standardized assessment, including a mathematics portion, typically taken in high school. The SAT Mathematics is a 58 question, 80-minute test, and is scored on a scale of 200-800 (The College Board, 2017).

Summary of Chapter One

The purpose of this study was to investigate the outcomes of the mathematical pathways students take that result in students enrolling in AP Mathematics courses during grade 11 or 12. It examined the differences in scores based on student enrollment in AP courses between pathways (students who enrolled in algebra 1 in grade 8 and those who enrolled in algebra 1 in grade 9) and gender (male, female). The study also allowed the researcher to analyze differences in student achievement (STAR Assessment, SAT Mathematics test, and AP tests) between pathways (students who enrolled in algebra 1 in grade 8 and those who enrolled in algebra 1 in grade 9), and gender (male, female). The intention of this study was to provide decision makers with valuable research on the outcomes of these two pathways.

CHAPTER TWO: A REVIEW OF THE LITERATURE

A comprehensive search was conducted in completing this review of the literature. The most common search words included acceleration, mathematics, gender, AP scores, SAT scores, and algebra 1. Searches were conducted through Google, Google Scholar, Ebsco, Ebsco Combined Host, Sage, and Jstor. Many articles and studies were found referencing acceleration. Some were from the pre-Common Core State Standards (CCSS) era and others have been published post-CCSS. The CCSS shifted many algebra-based standards into the regular eighth grade core math content. An investigation of studies included 19 studies focused on gender and mathematics, grade levels when algebra was completed, outcomes of Advanced Placement and other testing outcomes, as well as implications of the Common Core shift. One study can be found under both the gender heading as well as the placement and acceleration heading due to the outcomes of the study. The researcher also signed up for an email service through academia.edu that sent pertinent studies from its database when the studies matched the researcher's key words.

Theoretical Foundation

Developmental Readiness and Identity

Erikson's stages of development, specifically the adolescent stage, are manifested throughout studies on mathematical readiness and acceleration. Erikson provided a focus on identity formation and defined it as

> a process of simultaneous reflection and observation, a process taking place on all levels of mental functioning, by which the individual judges himself in light of what he perceives to be the way in which others judge him in comparison to themselves and to a typology significant to them; while he judges their way of judging him in the light of how

> he perceives himself in comparison to them and to types that have become relevant to him. (1968, p. 22)

Many students who are identified for an accelerated mathematics course will thrive academically and socially because it is the correct level of challenge. Some students may believe their peers will perceive them as being too smart and they might be concerned that placement in the course could lead to teasing and ridicule. Other students may feel embarrassed, thinking they are being judged for not being smart enough if they are not placed in an accelerated course. These self-perceptions could influence a student's decision to remain in certain mathematics pathways regardless of their developmental readiness for the advanced mathematics.

There are many influences on adolescent development according to Erikson. One influence is that of older generations, another is the media. There are also cultural and historical influences that factor into this identity formation and impact a person's self-esteem. Many of these cultural influences begin far earlier than adolescence and have been in existence in societies for generations through the existence of child training. Child training is defined as "the method by which a group's basic ways of organizing experience, or what we may call group identity, is transmitted to the infant's early bodily experiences and, through them, to the beginnings of his ego" (Erikson, 1968, p. 47). As children grow and develop, they begin to synthesize experiences on an individual level, while also recognizing this self-development and identity formation is a "variant of a group identity" (Erikson, 1968, p. 49). Being placed in or not placed in an accelerated mathematics class makes students part of a group and therefore impacts their identity. Nunn & Project Muse (2014) brings this idea to current times, stating "we are continually at work making meaning out of our interactions (with both other people and institutions) and crafting our identity in response to those meanings" (p. 133). In a study on

tracking in mathematics classrooms, Morrison (2011) found that “an entire hierarchy of social status had evolved around these math groupings” (p. 28). Coleman and Southern (2006) consider self-identity in students and caution that the environmental influences on children at a young age can be detrimental if students are not encouraged to become successful academically especially in the areas of mathematics and science. The way students perceive themselves and each other is greatly influenced by group identity.

Lewis (2024) breaks down Erikson’s stages of developmental readiness. When Lewis wrote about the stage right before adolescence, 5–12-year-old children, she included “your child may start comparing themselves to others. If they decide that they’re doing well scholastically, on the sports field, in the arts, or socially, your child will develop feelings of pride and accomplishment” (Stage 4 section). If a child is doing well in mathematics, they may be ready to continue to more challenging courses. Lewis continues to say “however, if you notice that your child struggles in one area, look for another area in which they can shine.” (Stage 4 section). Mathematics may be a struggle for students in middle school, but it does not mean students might not be ready for more advanced mathematics at a later stage.

The adolescent stage in Erikson’s theory includes 12 to 17-year-old children. It is a time where children are discovering their own identities, but they can also be highly influenced by other social groups (Coleman & Southern, 2006; Cross, 2001; Halpern et al., 2007). Cross also points out that puberty plays a role in the “predictability and understandings” that children experience. This idea that children are experiencing such identity crises in their lives throughout the adolescent stage supports the fact that there are many children who eventually register for AP courses by the end of high school who did not participate in an accelerated course in middle school. For many adolescents, it may take five years to begin to form their own

identity. Colangelo et al. (2004, Vol. 1) asserts that acceleration helps to address identity formation as it "provides a better personal maturity match with classmates" (p. 2).

Research Related to Implications of the Mathematics Sequence at the Secondary Level

Gender

One variable in the forefront of acceleration research is gender (Brimeyer, Schueths, & Smith, 2014). Gender differences have been analyzed in mathematics for years. From differences in learning styles, course enrollments, and achievement levels, gender has been a common thread of interest. Gender is often studied regarding the gender gap that has been present for years especially in the fields of Science, Technology, Engineering, and Mathematics (STEM; Robelen, 2012). In 2007, one global assessment, the Trends in International Mathematics and Science Study (TIMSS), yielded results in some countries with either no gender disparities or higher score outcomes for females. These patterns were not found in the United States (Robelen, 2012). The gender differences in achievement continue to be significant where standardized test scores are concerned, but females, on average, have started taking a greater number of mathematics and science credits than males as well as earning higher overall averages in the courses (Robelen, 2012). In response to some disparities in marginalized groups, the College Board conducted a study in the early 2000s about "stereotype threat," which is defined as a type of anxiety that occurs "when individuals in a certain population group, such as racial and ethnic minorities or females, face a situation in which they may be judged by a negative stereotype" (Robelen, 2012, n.p.). Some researchers believe this can negatively impact a student's performance on high-stakes assessments.

Brimeyer et al. (2014) conducted a study at a regional state university comparing attitudes and backgrounds of honors students compared to non-honors students. The results

indicated the honors population had a greater female population. Females made up 63% of the honors students while males made up 37% and females made up 52% of the non-honors population while males made up 48% of the population. Brimeyer et al. (2014) also researched differences in characteristics of honor students and non-honors students. After implementing an ordinary least squares regression to control for gender, race, parents' education levels, family income, and year in school, there was a significant difference in each of the variables they measured. Non-honors students reported they were more easily distracted in class (m = 4.75, SD = 1.36) and were more concerned about GPA (m = 3.91, SD = 1.35) than honors students (m = 3.71, SD = 1.61; m = 2.89, SD = 1.18) respectively.

Boaler (2002) conducted a study on gender identity and learning styles. The study consisted of interviews of boys and girls in two different school systems where teachers had very different teaching styles. One school, Amber Hill, followed a traditional approach and often provided students with lessons from a textbook. The other school, Phoenix Park, followed a problem-based, collaborative approach. At Amber Hill, a majority of the girls struggled in the upper-level mathematics classes due to the "fast and procedural teaching approach" (p. 145). The study showed girls displayed a tendency and desire to understand the concepts while boys just wanted to get the answers. Due to the fast pace of the course, girls struggled to keep up and experienced greater instances of anxiety. At Phoenix Park, the girls thrived in the project-based, cooperative learning environments, but it was thought that "some of the boys lacked the maturity to take responsibility for their own learning" (p. 149). The Phoenix Park boys displayed a more positive view of this style of learning by grade 10, perhaps suggesting they were more developmentally ready to take on the challenge.

One study by Liang et al. (2018) centered on how academic entitlement plays a role in self-perceptions of honors students. It found that males perceived themselves as being more academically entitled than females. It also found more females than males were apt to believe this notion: males are more academically entitled than females. Other research showed the gender gap is beginning to close at an algebra 1 level but not for upper-level mathematics courses (Liang et al., 2018). In 2015, girls and boys scored the same on the eighth-grade assessment from the National Assessment of Educational Progress (NAEP), but scores of females were lower by one point in 2017 (U.S. Department of Education, no date). A study of SAT scores by gender showed in the early 1980s, the number of males to females scoring over 700 was 13:1, but 25 years later, it dropped significantly to 3:1 (Halpern et al., 2007). There is no significant research as to why this gap has narrowed, but hypotheses include access to similar coursework for males and females along with special programs and mentoring to encourage females to pursue higher level mathematics courses. While males are still outperforming females in the U.S. some studies are finding the number of females enrolled in higher level mathematics courses is growing (Brimeyer et al., 2014; Corra, Carter, & Carter, 2011; Dougherty, Goodman, Hill, Litke, & Page, 2017; U.S. Department of Education, no date). Further investigation needs to be done involving gender in high level mathematics courses.

Corra et al. (2011) analyzed enrollment for students in AP classes as well as outcomes for students by race and gender on the SATs. Initial review of enrollment revealed overall White students were much more represented in AP classes than Black students, but for both races, the female enrollment was higher than the male enrollment for all classes. A chi-square test with $p < .001$ was used to compare the observed and expected values for students enrolled in the AP classes. For mathematics, the White males had an observed value of 849 and an expected value

of 517 with a residual of 323, the White females had an observed value of 876 and an expected value of 815 with a residual of 61, indicating higher than expected enrollments. The Black males had an observed value of 108 and an expected value of 278 with a residual of -170 and the Black females had an observed value of 164 and an expected value of 378 with a residual of -214, indicating lower than expected enrollments. Means were reported for each group for SAT scores. Black females (m = 429.6) outperformed Black males (m = 407.2), but White males (m = 557.2) outperformed White females (m = 502.4).

The studies about gender identity are summarized in Table 1.

Table 1

Studies Related to Gender Identity and Mathematics Course Enrollment

Reference	Type	Sample	Data Collection	Results
Boaler, 2002	Longitudinal, grades 6-10	181 participants from Amber Hill and 107 participants from Phoenix Park	Questionnaires and assessments including open, closed, authentic, and standardized.	At Amber Hill girls displayed a tendency and desire to understand the concepts while boys just wanted to get the answers. Due to the fast pace of the course, girls struggled to keep up and experienced greater instances of anxiety. At Phoenix Park, the girls thrived in the project-based, cooperative learning environments, but it was thought tha "some of the boys lacked the maturity to take responsibility for their own learning."
Brimeyer et al., 2014	Comparison of means, ordinary least squares regression	513 students in 2010 and 408 students enrolled in 2012 in a regional state university	Questionnaires, a self-reported academic entitlement survey, GPA	The research project focused on the differences between honors and non-honors students' attitudes and behaviors. This study found that the honors students in the program did have significantly different attitudes and behaviors.
Corra et al., 2011	Chi-Square	5470 students from a school district in eastern N.C.	Course enrollment data in AP courses and SAT scores	Females were enrolled in AP classes at a higher percentage than males. Black females scored higher on the SATs than Black males, but White females scored lower than White males.
Liang et al., 2018	Longitudinal Study	209,364 students	Assessment records were obtained from the state of CA	Males perceived themselves as being more academically entitled than females. The gender gap is beginning to close at an algebra 1 level but not for upper-level mathematics courses.

The Advanced Placement (AP) Program

The Advanced Placement (AP) Program was designed to provide high school students with early access to college level courses (Judson & Hobson, 2015; Morgan & Klaric, 2007). Earning a score of three or higher on an AP assessment equates to college credits at many

colleges and universities. This means students could have fewer credits to pay for and often enter college in higher level classes. Morgan and Klaric's research, published by the College Board, has indicated students who take AP courses in high school generally fare better in college than peers who did not take AP classes in high school. Their study included 72,457 participants representing 27 different post-secondary institutions and included 5 research questions covering various aspects of the AP Program and the after effects in college. The first question investigated achievement in an intermediate college course, comparing those students who took an intermediate level course initially since the AP course was their introductory level course and those students who took both an introductory level course as well as an intermediate level course in college. Overall GPAs for the courses were compared after using SAT scores to adjust for differences and still the students who had taken an AP course in high school performed better. Specifically for Calculus AB (n = 5,932) the average non-AP student's course grade was 2.43 on a 4-point scale and the average difference for a student scoring a 3 was +.26, a 4 was +.47, and a 5 was +.91. For Calculus BC (n = 5,411), the average non-AP student's course grade was 2.50 on a 4-point scale and the average difference for a student scoring a 3 was +.50, a 4 was +.95, and a 5 was +.96. All these increases were significant at the $p < .05$ level. Even after adjusting for differences in SAT scores, the AP student's course performance remained significantly higher on all accounts. AP students graduated earlier than non-AP students and took more courses in the area of their AP exam than did non-AP students.

In addition to benefits to students, there is also money involved. In the past, there has been federal money allocated to supporting states' expansion of AP programs as well as money to cover student testing fees for low-income students (Theokas & Saaris, 2013). Much of this money was in response to attempts at closing the gap for students of different races and lower

income levels. In the 2009-2010 school year, 71% of all public schools in the U.S. offered at least one AP course, but only 11.7 percent of students attending those schools enrolled in at least one AP class. Similar efforts are ongoing more locally. In 2022, the Connecticut State Department of Education (CSDE) in conjunction with the College Board "cover[ed] the entire cost of the 2023 AP exam fees for all students from low-income families who attend public school in Connecticut" (CSDE, 2022). Some efforts to increase enrollment have included but are not limited to; open access policies, automatic enrollment in an AP course when meeting proficiency on other indicators, outreach and recruitment through one-on-one and small group conversations, and curriculum redesign. While enrollment in AP classes has increased, there has been a decline in the overall percent of students passing (score of 3 or above) an AP exam (Judson & Hobson, 2015). In 1992, 65.5% of students passed their AP exam, but by 2012, only 59.2% passed. This significant decrease was shown through regression analysis ($R^2 = .84$, $p < .001$). While many states and school districts have taken advantage of the supports available for increasing AP enrollment, more research needs to be done on the outcomes of these supports and initiatives. Table 2 includes scores obtained from the College Board website on passing rates for the AP Mathematics exams from 2018 through 2024 (The College Board, no date).

Table 2

AP Mathematics Assessment Pass Rates

Course	2018	2019	2020	2021	2022	2023	2024
AP Calculus AB	57.70%	58.40%	61.40%	51.00%	55.60%	58.00%	64.40%
AP Calculus BC	79.70%	81.00%	81.60%	75.20%	76.90%	78.50%	80.90%
AP Statistics	60.70%	59.70%	60.00%	57.90%	60.40%	60.00%	61.80%

The pros and cons of the AP program extend beyond the scores, achievement levels, and incentive programs. Foust, Hertberg-Davis, and Callahan (2009) explored student perceptions of

the AP program and found many pros and cons. The pros included a better class atmosphere, the special bond with classmates and teachers, an increase in pride and self-confidence. The cons included the perception of an unflattering stereotype for students taking advanced coursework, a heavy workload, and an increase in stress and exhaustion. Colangelo et al. (2004, Vol. 1) described many benefits of AP courses. One is that students who want to remain in high school can still do so while typically earning college credit. Another benefit is a greater likelihood of earning a bachelor's degree. Students taking no AP courses were only 33% likely to earn a bachelor's degree, while those taking one or two AP courses had a 59% and 76% chance, respectively, of earning the same degree. This may be due to the fact that AP courses help prepare high school students for college level work. Another advantage of acceleration is that it can lead to early entrance into college, which can then lead to an earlier start to a career (Colangelo et al., 2004, Vol. 1).

The studies about AP Programs are located in Table 3.

Table 3

Studies Related to AP Programs

Reference	Type	Sample	Data Collection	Results
Foust et al., 2009	Qualitative analysis	84 students from four sites participated. Students were enrolled in AP or IB courses and represented the diversity in gender and ethnicity in their schools, 57% (n = 48) of the participants were female.	In depth interviews with students	Advantages and disadvantages of AP or IB programs emerged. Advantages included a better class atmosphere, a special bond between participants, and pride and self-confidence as a result of more challenging work. Disadvantages include the perceptions of unpopular stereotypes, larger workload, and stress and fatigue.
Judson and Hobson, 2015	Exploratory study	All students who took an AP test from 1992 to 2012	AP data were collected from the College Board. Databases were culled from various College Board publicly available and requested reports.	There was an increase in student enrollment in AP. Regression analysis revealed a significant negative trend (R^2 = 0.84, p < .001) in AP scores.
Morgan and Klaric, 2007	Regression analysis	72,457 participants representing 27 different post-secondary institutions	Data from 27 colleges and universities (names, social security numbers, courses taken and grades, gender, race/ethnicity, majors, graduation dates, and college entrance scores) were collected and matched with data from College Board.	Students with AP grades of 3 or better had higher grade averages in intermediate college courses than did the non-AP student. AP students graduated earlier than non-AP students. AP students take on considerably more course work in the area of their AP Exam than do non-AP students.

Acceleration and Placement

With an accelerated mathematics course in seventh grade, the typical next step is eighth grade algebra. The research is split over the costs and benefits of algebra in eighth grade. Some describe early exposure as critical (Olszewski-Kulbilius, Subotnik, & Worrell, 2016). Others caution that if algebra is the new norm for eighth grade, then "provisions must be made for students who can move beyond this newly designated mastery goal" (Spielhagen, 2006b, p. 40). School districts must handle placement and acceleration for students with care to make sure all students are getting the instruction they need to be successful.

There exists an underlying assumption involved in placement debates that there is a specific course sequence that students should complete to best prepare them for college (Showalter, 2017). This course sequence is sometimes referred to as the "algebra-calculus pipeline" (Showalter, 2017, p. 675). While there are placement concerns regarding this pipeline, the debate begins much earlier. Many studies have been conducted nationally, regionally, or locally resulting in varying outcomes. The objective is to enable "researchers [to] identify specific areas of mathematics that consistently predict later mathematics proficiency, after controlling for other types of mathematical knowledge, general intellectual ability, and family background variables" (Siegler et al., 2012, p. 691). Such research plays a pivotal role in informing the ongoing debate surrounding student placement.

Some districts have adopted an all or nothing approach to acceleration in middle school. Spielhagen (2006a) and Kriegler and Lee (2006) reported neither extreme is the best, and that acceleration may be right for some but not all. Spielhagen's research supported the idea that eighth grade algebra is not necessarily the right course for all students, but there were likely more students capable of it than are typically placed in it. Kriegler and Lee found that placing

students who scored below or far below basic on their state's proficiency exam in seventh grade yielded below proficient results in algebra in eighth grade as well.

Loveless (2021) summarizes the ongoing debate about acceleration, stating "a century of research has not quelled the controversy surrounding the use of tracking in schools" (para. 16). Loveless describes tracking as "differentiating students in terms of their skills and knowledge" (para. 3). Students are often chosen for accelerated mathematics classes based on success with prior mathematical skills and knowledge. Loveless claims that one of the challenges to research on tracking is the claim that "high-track students learn more than low-track students may simply be an extension of how the students were 'selected' into respective tracks in the first place and may have nothing to do with tracking itself" (para. 8).

Some schools and districts have made decisions to accelerate all or none of their students. Districts have seen success with both policies. Sawchuk (2018) details the decision of the San Francisco school district to de-track all mathematics classes. Early evidence showed improvement for many marginalized students, however, there was little to no difference for students who would have traditionally been accelerated. The decision in San Francisco to reverse an earlier push for all eighth graders to take algebra was due in part to the adoption of Common Core State Standards in 2010. Many topics that were traditionally found in typical algebra courses are now interspersed throughout the grade 8 standards.

Selection criteria for accelerated courses varies throughout the country and sometimes even within the same district (Spielhagen, 2006b). Often students who might have been capable of success in a grade 8 algebra course are left out. Different policies have been implemented to try and mitigate this and ensure all students have opportunities to access upper-level mathematics. Open enrollment policies allow students to take AP courses even if they have not

previously been in challenging mathematics courses in the past. Some scholars have claimed that "non-honors students' education is enhanced through exposure to honors students" (Brimeyer et al., 2014), while others claim that many highly capable students who are "forced to follow the curriculum for their age-peers" (Colangelo et al., 2004, Vol. 1, p. 53) will be bored. Evidence for accelerating all students comes in multiple forms, one example being, non-honors students benefiting from the higher-level questions that honors students ask and the advanced course content and delivery (Clauss, 2011). Spielhagen (2006a) claims that algebra is "the gatekeeper to more advanced courses" (p. 34) and hypothesizes that mathematical literacy will improve with more eighth graders taking it. Many students who do not take algebra in eighth grade need to "double up" on mathematics courses in high school, taking two courses simultaneously, if they wish to reach calculus.

Spielhagen (2006a) concludes "appropriate challenging mathematics instruction should be provided for all students when they need it and not be restricted to longstanding traditional curriculum designs" (p. 57). Not every student is emotionally and psychologically ready for challenging mathematics content acceleration in middle school, but that should not prevent them from taking AP courses later in their secondary mathematics career.

Howell (2019) conducted a study regarding AP scores of students who had enrolled in an AP class under traditional criteria (a grade of B average or better) compared to those that had enrolled in an AP course without having met traditional requirements (a grade of B- average or less). Howell's study analyzed four different AP exams; AP calculus AB, AP English language and composition, AP physics 1, and AP United States history. The AP calculus results are described further. In the study, there were $n = 486$ students enrolled in AP calculus. The first research question analyzed "the relationship between the type of student (traditional versus

nontraditional) and student achievement as measured by AP exam scores" (p. 89). The mean for all students on the 2016-2017 Calculus AB exam was 3.84 out of 5 (*SD* = 1.12). Through an independent t-test $t(484) = -5.051$, $p < .001$, it was found that there was a statistically significant difference between the AP scores, with traditional students having a mean score of 3.94 out of 5 (*SD* = 1.09) as compared to nontraditional students who had a mean score of 3.23 out of 5 (*SD* = 1.09) and $p < .001$. The second research question addressed "the relationship between the type of student (traditional versus nontraditional) and student achievement as measured by AP exam scores when controlling for GPA, PSAT/NMSQT, student SES, and prior AP experience" (p. 92). Through a multiple regression analysis, it was found that the type of student (traditional versus non-traditional) was not a predictor of AP achievement when correlated with overall GPA, PSAT/NMSQT, student SES, and prior AP experience. Only PSAT scores and overall GPA were found to be significant predictors of AP Achievement.

Liang et al. (2018) studied different factors impacting student success in algebra. The study took place in California and included over 200,000 student records. The researchers analyzed many variables to determine which may be used as predictive variables of student success in eighth grade algebra. Some of these variables included: the prior year's California State Test scores (CST) for both English language arts and mathematics; various subscores in mathematics from the CST; and several demographic factors. Three different models of analysis were used in this study. One was a comparison of grade 7 mathematics raw scores with grade 8 algebra 1 raw scores. The analysis of scores supported the idea that the seventh-grade assessment was a strong predictor of the algebra 1 score. A second model specifically addressed the predictability of the subscores of the Mathematics CST and a third model involved demographic information and ELA scores in combination with the grade 7 sub-scores as

predictors. With the exception of American Indian and unknown ethnicity groups, all other ethnicity groups had large enough representation to show statistical significance at $p < .0001$. From the grade 7 assessments to the grade 8 assessments, there was a moderate significant correlation between the ELA scores as well as each of the sub-scores for the mathematics assessment. The strongest correlation between grade 7 and 8 was *rational numbers* with a Pearson *r* correlation coefficient of .690. The next greatest predictor was the ELA score. Regarding the outcomes of demographics impacting student success rates, some demographic characteristics yielded positive coefficients and others, negative, however, demographics only resulted in a 2.3% increase in the overall prediction of algebra 1 scores.

Siegler et al. (2012) used two different longitudinal data sets to explore predictors of high school mathematics success. Using the British Cohort Study (BCS) and the Panel Study of Income Dynamics-Child Development Supplement (PSID-CDS), Siegler et al. analyzed standardized assessment scores and demographic information for 3,677 students from the United Kingdom and 599 participants from the United States. It was found that "knowledge of fractions at age 10 would predict algebra knowledge and overall mathematics achievement in high school, above and beyond the effects of general intellectual ability, other mathematical knowledge, and family background" (Siegler et al., 2012, p. 693). The relation between fraction knowledge and algebra was significant in the U.K. $r(3675) = .68$, $p < .001$ and the U.S. $r(597) = .65$, $p < .001$. The correlation was even stronger between fraction knowledge and general mathematics achievement; the U.K. $r(3675) = .81$, $p < .001$ and the U.S. $r(597) = .87$, $p < .001$. Knowledge of long division was the second strongest predictor of overall mathematics achievement; U.K. $r(3675) = .59$, $p < .001$ and the U.S. $r(597) = .69$, $p < .001$. These consistent results across data

sets from two countries may lead to more objective and consistent placement criteria in the future.

In the 2010-2011 school year, a policy was put into place in Wake County, North Carolina where placement decisions for student acceleration were more objective than subjective and targeted placement occurred based on scores (Dougherty et al., 2017). A longitudinal study was done to assess the impacts of this policy. Student data about course enrollment, class averages, and end of year assessment scores were collected from two cohorts of students beginning with seventh grade and concluding with the eleventh grade. This study included over 3,000 students and used a regression discontinuity design. A policy stated that students would be enrolled in the accelerated track based on their predicted success rate for algebra 1 as determined by prior test scores. Students needed to achieve at least a 70% probability rate. Using these criteria, 80% of students were eligible for acceleration. Data were collected for all students, but an emphasis of the analysis was placed on the students closest to the threshold scores.

The data analysis provided many outcomes. One finding was that while most of the students typically passed the accelerated course, many did not excel in it. There was no significant difference in standardized assessment scores at the end of eighth grade between students who had been accelerated in seventh grade and those who had not. Another result of this study was that while the income and race gaps of the enrolled populations were more equitable as a result of the policy, the overall success rates based on income and race still resulted in a gap particularly when looking long term. By the time students enrolled in pre-calculus in grade 11, of the original non-low income students, 40% remained, whereas only 5% of the original low income students remained. While 90% of the students passed the initial accelerated course, only 11% of them passed with As or Bs. As the students progressed through

grade 11, only 63% of the initially accelerated students remained in an accelerated track the following year, and that continued to decline until grade 11, when only 14% of the initial students were enrolled in pre-calculus. Despite these declines, there was a small but significant increase in the number of students who were taking more college preparatory level courses by the end of high school.

There were some significant results in terms of gender. A greater percentage of female students, 53%, remained in the accelerated courses as compared to their male counterparts, 32%. Female students were also found to have a greater pass rate in the initial accelerated course by 15% as compared to the male students.

In an earlier publication, Dougherty et al. (2017) concluded "students on the margin of eligibility and who participate in advanced mathematics in middle school may experience negative effects as a result of being in a peer group of more advanced ability, on average" (p. 4). They went on to make connections to student self-perception and peer comparisons similar to the theory addressed in this study. They added "we hypothesize that the negative effects may transfer as a result of a suboptimal match of ability or through negative psychological impacts of perceiving oneself as less able than your peers" (p. 4).

A longitudinal study including 21,260 kindergarteners, representing 1,277 schools and 100 counties began in the Fall of 1998 (Domina, 2014). The final *N* was 6,425 due to attrition. There were many outcomes of this study. Males were found to be overrepresented in eighth grade geometry classes. When socioeconomic status was compared to mathematics placement it was found that "students in eighth grade general mathematics classes come from considerably less affluent and less highly educated families than their peers in eighth grade algebra and geometry" (Domina, 2014, p. 1954). By the end of eighth grade, the achievement gap, as

measured by the mathematics assessment data from the panel data from the nationally representative Early Childhood Longitudinal Study's Kindergarten Cohort (ECLS–K), between students enrolled in geometry and students in a core mathematics course was almost a full standard deviation apart. One of the "most striking aspects of this model is its low R^2, which indicates that student age, ethnicity, gender, parental education, family income, age, family income, and school poverty together explain just 3% of the variance in eighth-grade mathematics course placements" (Domina, 2014, p. 1956). The research also indicated "the associations between fifth grade mathematics test scores and student odds of enrolling in eighth grade algebra and geometry are particularly large and statistically significant at 0.63 and 0.76, respectively" (Domina, 2014, p. 1956). Reading skills also influenced course placement. The overall indication was that access to advanced courses was greatly based on student achievement, but it was not clear if the actual placement in the courses improved success as measured by test scores or if it is just that most accelerated middle school classes had already "plac[ed] students with relatively high levels of mathematics skills, interests, and motivation into accelerated algebra and less high-achieving students into grade-level courses" (Domina, 2014, p.1950). Some of the data even indicated that students in advanced courses have less growth in achievement than their general education classmates. This study also connected to the theory of developmental readiness. In some of the concluding remarks of this study, Domina states, "If some of the positive consequences of advanced course enrollment are contingent on student readiness, efforts to accelerate middle school mathematics curricula may see diminishing returns if they lead students to enroll in courses for which they are unprepared" (Domina, 2014, p. 1962).

Criteria for placement in accelerated programs can be based on many different variables, some more objective than others. Standardized testing is one of the more objective variables.

While there is a plethora of different standardized tests blanketing the U.S. in elementary and secondary schools, one study sought to assess the predictive value of the PSAT tests on AP exam performance (Richardson, Gonzalez, Leal, Castillo, & Carman, 2016). This study focused on the push in school districts to increase AP enrollment in order to help prepare students for college. The intention of the study was to determine if the PSAT could be used as a less-biased criterion for enrollment into AP courses. The study focused on students in a large urban area in the southeastern United States who had taken the PSAT and one or more AP exams in either Calculus, Biology, or U.S. History. There were 1,502 participants in this study of which 923 students took the AP calculus exam. The results of a multiple regression analysis indicated all the components of the PSAT were significant ($p < .05$) indicators of success on the AP calculus exam. The main demographic predictor was ethnicity, however socioeconomic status was not a significant predictor.

While the PSAT may have been a good indicator for success on certain AP exams, it is not the only indicator. In a study done to assess effective mathematics curriculum in secondary schools, it found the actual curricular program used to teach mathematics had little effect on the outcomes for students, with a weighted mean effect size of +0.03 for 40 studies (Slavin, Lake, & Groff, 2009). In the discussion of this study, it was noted it is possible that some of the standardized tests used as the instruments to measure outcomes might not capture "more sophisticated skills" the curricula aimed to address (Slavin et al., 2009, p. 887). Using standardized assessments to measure outcomes of any program of study can be beneficial because they are standardized by definition, but can also pose limitations in that there is only so much they can capture.

Highlights of each empirical study in this section are indicated in Table 4.

Table 4

Studies Related to the Outcomes of Mathematical Acceleration and Placement

Reference	Type	Sample	Data Collection	Results
Domina, 2014	Longitudinal Study	Sample: 21,260 Kinder-garteners from 1,277 schools in 100 U.S. Counties, Final N=6,425 due to attrition	Data gathered five times: K, 1, 3, 5, and 8.	Boys were overrepresented in 8th grade geometry. Students in general 8th grade math classes come from less affluent and less highly educated families. The achievement gap between 8th grade students enrolled in general math and in geometry is almost a full standard deviation.
Dougherty et al., 2017	Regression Discontinuity Design	North Carolina School District with 20,800 students. Sample size 3,333.	Sample was chosen from students scoring 15 points above or below acceleration threshold score. Transcripts were observed for course enrollment and achievement.	Due to poor academic performance, 62% of accelerated 7th graders remained in an accelerated path taking algebra 1 in grade 8. No significant differences between accelerated and not accelerated students in state test scores at the end of grade 8.
Howell, 2019	Non-experimental, correlational, explanatory study	AP calculus AB students	AP scores were collected from the 2016-2017 school year and compared between the traditional and nontraditional (less than B- average in prior courses) students	Traditional students significantly outperformed nontraditional students. The population was *n* = 486. Traditional mean score = 3.94 (*SD* = 1.09) and nontraditional mean score = 3.23 (*SD* = 1.09), but when controlling for GPA, PSAT/NMSQT. student SES, and prior AP experience, the type of student had no significant influence on student achievement on

Reference	Type	Sample	Data Collection	Results
				AP calculus AB exam scores.
Kriegler and Lee, 2006	Comparison of stacked bar graphs	112 randomly selected middle schools in greater Los Angeles area	Student grade levels and California state test (CST) scores in mathematics	Only half of the students were completing algebra in 8th grade and less than half of those students are meeting proficiency. 90% of schools with conservative algebra placement policies saw an increase in the number of proficient students or a decrease in the number of non-proficient students, while only 20% of schools with more aggressive algebra placement policies saw the same outcomes.
Liang et al., 2018	Longitudinal Study	209,364 students	Assessment records were obtained from the state of CA	Performance with rational numbers was the strongest predictor of algebra scores (48% of the variance) and quantitative relationships was the second strongest predictor (8% of the variance). All demographic variables accounted for 2.3% of the variance in the criterion.
Richardson, et al., 2016	Multiple Regression Analysis	1,502 participants from a large urban area in the southwestern United States	PSAT and AP exam scores were obtained along with ethnicity and socioeconomic demographics	All the components of the PSAT were significant ($p < .05$) indicators of success on the AP calculus exam. The main demographic predictor was ethnicity. Socioeconomic status was not a significant predictor.
Sawchuk, 2018	Cohort match comparison	56,000 students in the San Francisco	AP scores and repeat failure rates were obtained	Data showed the number of students repeating algebra fell among all ethnic and racial groups

Reference	Type	Sample	Data Collection	Results
		school district		and fewer are receiving Ds and Fs in algebra 1. While the Black student population has shown improvement in earning math credits, the gains have not shown up on state assessment scores or enrollments in AP calculus courses.
Siegler et al., 2012	Longitudinal study	3,677 British Cohort Study (BCS) participants and 599 Panel Study of Income Dynamics-Child Development Supplement (PSID-CDS) participants	Assessment and demographic data were pulled from two nationally representative data sets; the BCS and PSID-CDS.	Knowledge of fractions at age 10 predicted algebra knowledge and overall mathematics achievement in high school, above and beyond the effect of general intellectual ability, other mathematical knowledge, and family background. Early knowledge of whole number division was related to mathematics proficiency later in high school.
Slavin et al., 2009	Best evidence synthesis	A review of 26 studies that used randomized or matched control groups, lasted at least 12 weeks, and had equality at pretest	Studies were found through the What Works Clearinghouse and NRC. Electronic searches were made of educational databases (JSTOR, Education Resources Information Center, EBSCO, PsycINFO, Dissertation Abstracts), Web-based repositories (Google, Yahoo, Google Scholar), and education publishers' Websites.	There is a lack of evidence that it matters very much which textbook schools choose (weighted mean *ES* = +0.03 across 40 studies). Eight studies found cooperative learning programs that focus on teachers' instructional behavior as opposed to just mathematics content impactful (weighted mean *ES* = +0.42).

Pathways and CCSS Shifts

The National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) released a joint statement in 2012 encouraging secondary schools to provide students with foundations necessary to be successful in Calculus at a post-secondary level (MAA & NCTM, 2012). Regarding the mathematics sequence in U.S. schools, Bressoud, Camp, and Teague (2012) stated,

> the pump that is pushing more students into more advanced mathematics ever earlier is not just ineffective: It is counter-productive. Too many students are moving too fast through preliminary courses so that they can get calculus onto their high school transcripts. The result is that even if they are able to pass high school calculus, they have established an inadequate foundation on which to build the mathematical knowledge required for a STEM career (p. 2).

In 2022, the MAA and NCTM updated their Calculus Position Statement, but it still had a similar outcome. The goal of high school should not be to take calculus, but rather to provide "a broad spectrum of mathematical preparation" (MAA & NCTM, 2022, p. 1) so students are prepared for mathematical success in post-secondary school. This may mean calculus is the path for some but may not be the path for others.

In a U.S. Department of Education Publication released in 2006, Adelman claims for students to have a decent chance of earning a bachelor's degree, they must take some mathematics beyond algebra 2. However, this does not have to be an AP course. In fact, the Common Core State Standards (CCSS) actually "represent less emphasis on advanced algebra and geometry than [prior] state standards" (Porter, McMaken, Hwang, &Yang, 2011, p. 115). Judson and Hobson (2015) pose the question of whether "providing a college-level course is the

same as readying a student for college" (p. 75). These statements, coupled with the varying policies among the 50 states in the United States provide a basis for reviewing the rationale for different pathways students take in middle and high school that lead to AP courses.

One study reviewed the academic pathways in secondary schools in each of the 50 states (Bragg, Kim, & Rubin, 2005). The purpose of this study was to "document and describe the purpose, goal, and features of models and programmatic approaches that emphasize college access and success in some way, including identifying public policies that supported existing and emerging academic pathways" (Bragg et al., 2005, p. 7). The pathway leading to AP courses was one of the nine major pathways to college reviewed in this study. Interviews were conducted with 129 state officials in each state as well as Washington D.C. to examine the different pathways to college that existed in each state. Member checking occurred with each of the interviews as well as triangulation with other state documentation. AP pathways were one of only three different pathways that were present in all 50 states. The AP pathway also received the highest percentage of use as a pathway to college to reach underserved students particularly due to the federal funding available to low-income students. While this study attempted to review policies in all 50 states, it was evident in many states the policies for pathways and acceleration are often left to the local decision makers and out of the hands of state officials.

Showalter (2017) conducted a study analyzing how mathematics course sequences in high school impacted student results on remedial mathematics placement exams in college. Using a propensity score analysis, no evidence was found to support continuing higher mathematics "in the algebra-calculus pipeline helped students to place out of postsecondary remedial mathematics courses" (Showalter, 2017, p.682). Showalter cautioned these results do not suggest there is no value in taking advanced mathematics courses, but only that there is no

significant effect on remedial mathematics placement at the college level. One explanation for this is while some students may not have furthered their mathematics skills along the algebra-calculus pipeline, it does not mean they did not enroll in some other applied mathematics course, such as; economics, woodworking, computer programming, mathematics of sports, or agricultural mathematics. Showalter's research contradicted efforts to mandate algebra 2 for all students prior to high school graduation. His research found it was "the students who were least likely to take an upper-level mathematics course who benefited least from each additional course taken in the algebra-calculus pipeline" (p. 686). Showalter acknowledged how difficult the decision making is for policy makers when it comes to standardizing course requirements for all students.

The CCSS were designed with the intention to reduce the number of concepts at each grade level to provide room for more depth and a deeper understanding of each concept (Jones & King, 2012). The design of the standards was also based on scholarly research, surveys of key stakeholders, and multiple national as well as international assessment data. College and university professors were a large percent of this stakeholder's group. This meant successful completion of CCSS assessments would show students were "ready to succeed in the most typical entry-level, credit bearing courses (e.g., freshman composition and college algebra)" (Jones & King, 2012, p. 41).

The adoption of the CCSS in many states in 2010 has rendered some of the research regarding acceleration out of date. Some of the research supporting a 2006 study on accelerating students mathematically through heterogeneous grouping discusses the importance of covering algebra-based topics in eighth grade (Burris, Heubert, & Levin, 2006). Adelman (2006) also touted that middle school mathematics courses needed more rigor and should have had an

algebra focus. In a study reviewing multiple mathematics textbooks completed in the 1980's, it was found that only 30% of the content covered in the average grade 8 textbook was new content (Flanders, 1987). These were critical supporting factors for acceleration in the era prior to the CCSS where content from multiple years could be consolidated and condensed due to the heavy overlap (Illustrative Mathematics, 2020). Topics and material taught in algebra courses prior to 2011 overlap greatly with current standards for eighth grade as defined by the CCSS. Dingman, Teuscher, Newton, and Kasmer (2013) delineated the shifts from prior state standards to CCSS in a comparative analysis study examining many different mathematical content strands. Multiple algebra topics were found to "have an increased emphasis in CCSSM in comparison to many states in the State Standards Analysis" (p. 557). In a study comparing alignment between prior state standards and CCSS in mathematics, it was found that the CCSS "represent a modest shift toward higher levels of cognitive demand than [were] currently represented in state standards" (Porter et al., 2011, p. 106). One of the writers of the CCSSM wrote "about half of the traditional algebra 1 course (linear functions and equations, systems of linear equations) is now included in the grade 8 content standards, along with serious work in statistics and geometry" (Daro & SERP Institute, 2014, p. 1). He also explains

> The critical content now incorporated into eighth grade math poses a challenge for districts: before the CCSS-M were adopted in most states, many students completed Algebra I by the end of eighth grade by skipping a course. With the adoption of CCSS-M, skipping is no longer feasible; every grade has essential content. Yet many parents believe that completing Algebra I by the end of eighth grade is what their children must do to be competitive when they apply to college. (Daro & SERP Institute, 2014, p. 1)

Illustrative Mathematics produced a document outlining guidance for accelerating students in mathematics (2020). In the document they detailed the shifts (see Figure 1) from where topics were typically taught prior to the adoption of the CCSS and where they are taught since the adoption of CCSS.

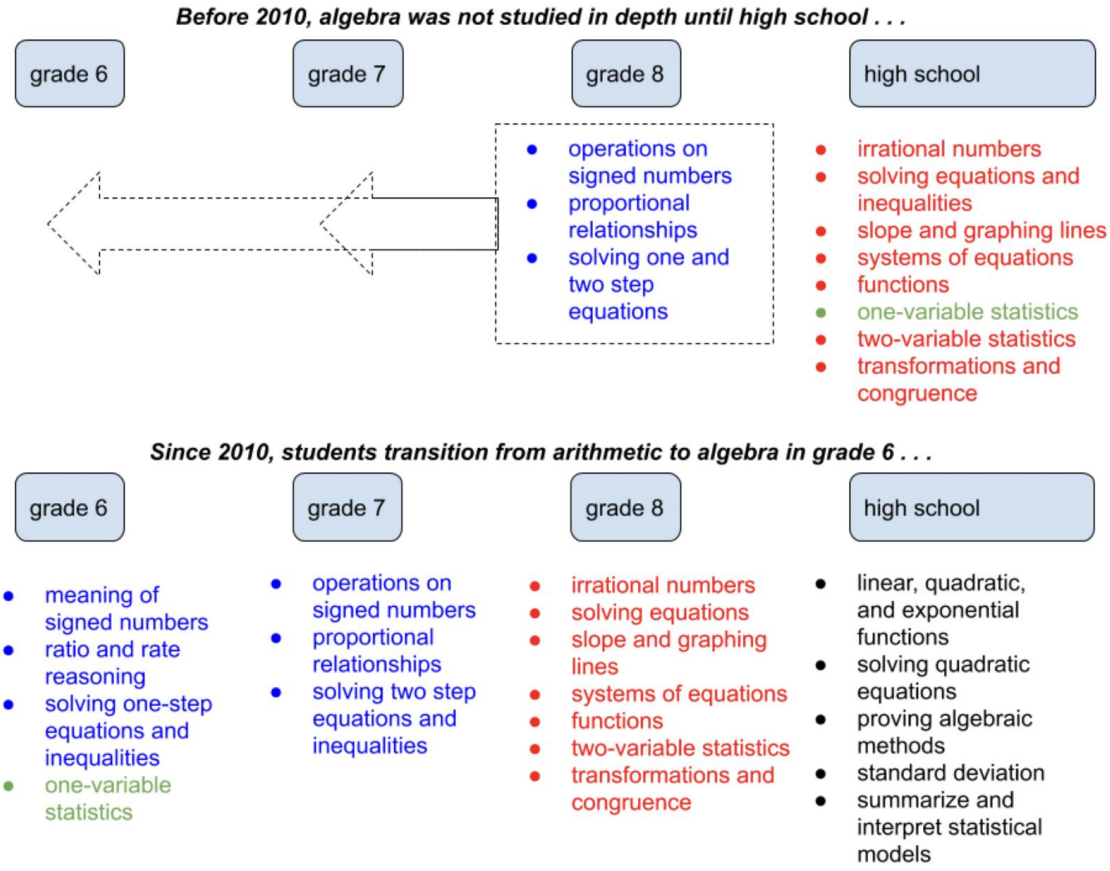

Figure 1. The Common Core shift. Adapted from "Guidance for Accelerating Students in Mathematics" by the team at Illustrative Mathematics, 2020. Reprinted with permission.

While Illustrative Mathematics provides suggestions and guidance for acceleration, the stance they take is the CCSS already provide an extensive dive into more traditionally algebra-based topics in eighth grade without having to involve an accelerated course. In a similar notion, "Algebra 1 is a much tougher course than what was taught previously in most states" (Heitin, 2015, p. 1).

Burris, Heubert, and Levin (2006) supported the idea that an enriched curriculum for accelerated students is the best curriculum for all students and that in eighth grade this curriculum should be algebra-based. Regardless of the curriculum shifts due to CCSS, the study Burris et al. conducted still contains pertinent information. The study aimed to answer the following questions: "would more students take and pass [higher level courses] if they took an accelerated algebra course in eighth grade?" and "would the performance of initial higher achievers decrease if all students were heterogeneously grouped and accelerated in mathematics?" (Buris et al., 2006, p. 107). The study was longitudinal, comparing two groups; (a) students entering sixth grade for the three years prior to 1995, when different tracking policies were in place and (b) students entering sixth grade in 1995 and the two years following, after a policy had been put in place to accelerate all students so they took the equivalent of an algebra 1 course in eighth grade. The study took place over a span of six years in which the curriculum did not change, the staff had very few changes, and the socio-economic status of the population remained relatively unchanged. Many data points were reviewed for this study. These included the mathematics sub score of the Iowa Test of Basic Skills for fifth grade, the Sequential Mathematics I regents exam in ninth grade, AP Calculus scores if applicable, mathematics courses taken in grades 8 through 12, year of entry into high school, and socioeconomic status in the form of free or reduced lunch qualification. Once data cleaning occurred there were 477 participants in the pre-universal acceleration cohort and 508 participants in the post. As a result of the universal acceleration shift, it was found that the number of students who took and passed advanced mathematics courses was significantly higher post universal acceleration. It was also found that the students who were in the upper stanine levels

either improved or remained statistically the same on multiple standards-based assessments post universal acceleration.

The debate is still ongoing regarding where the best place is for algebra to live (Heitin, 2015). While San Francisco initially had an algebra for all in grade 8 policy, as of 2015, they had adopted a new policy promoting algebra for all in 9th grade (Heitin, 2015). Heitin also noted throughout the United States from 1990 to 2011, the number of eighth graders taking algebra 1 or higher increased from 16% to 47%, but that number was expected to drop back down with the adoption of the CCSS (2015). Yoder (2025) reported by the 2020-2021 school year less than 24% of eighth graders were enrolled in algebra 1 nationwide. Yoder explained "Not all eighth graders are ready for the abstract concepts — like variables, linear functions, slope — that come with algebra I" (para. 3). He goes on to explain "those more complex ideas also require extended concentration, which is difficult for many middle schoolers" (para. 3).

Some schools continue to push for more and more students to take AP classes, while others are starting to shift towards career-based pathways. While students may not gain college credits through career paths, many are able to earn different industry certifications and go right into the workplace upon graduation (Jester, 2014). There are incentives for schools to increase AP enrollment. For example, one school district in Florida has an incentive to increase certification offerings. In Alachua County Public Schools, the school can earn money based on the number of students receiving certifications in different programs. Concerns were raised from the school superintendent about how colleges would look at the career paths compared to the scholar paths in the school district, but a university spokesman claimed "they look at what courses a student is taking, the rigor of the courses, how well the student is doing in those courses and whether that person has challenged himself or herself" (Jester, 2014, p. 2). The

Mathematical Association of America echoes these sentiments in regard to recommending high schools not teach Calculus but focus more on building strong mathematical foundations (Daro & SERP Institute, 2014). Daro also provides a recommended pathway for students to still reach AP classes without taking algebra 1 in eighth grade. He suggests algebra 1 and geometry to be taught in ninth and tenth grade, respectively. Daro's proposed schedule creates an opportunity in eleventh grade for students to either take a typical algebra 2 course, or one that is compressed and includes further topics that would prepare students for AP Calculus (Daro & SERP Institute, 2014; Heitin, 2015). AP Statistics could be taken through this model regardless of which algebra 2 course was chosen. Using the pathway Daro suggests would leave ample room for students to build their foundational mathematics knowledge and potentially make them more developmentally ready for AP classes by grade 12. Other schools have eliminated AP classes altogether claiming the rigor is not high enough or the course is too inflexible (Manzo, 2004). This is partly due to the fact that some colleges and universities will not even award AP credit or will only award it when the highest score category is attained (Manzo, 2004).

Highlights of each empirical study regarding the implementation and adoption of CCSS are included in Table 5.

Table 5

Common Core State Standards Shifts

Reference	Type	Sample	Data Collection	Results
Bragg, Kim, &r Rubin, 2005	Qualitative	129 State officials throughout the US	Data were collected through interviews including member checking and triangulation with other state documentation	AP pathways were one of only three of the different pathways that were present in all 50 states. The AP pathway received the highest percentage of use as a pathway to reach underserved students particularly due to the federal funding available to low-income students.
Burris, Heubert, & Levin, 2006	Longitudinal Study	477 participants in the pre-universal acceleration cohort and 508 participants in the post	Data were collected on students entering grade 6 for three years prior to an acceleration shift in 1995 and three years post.	The number of students who took and passed advanced mathematics courses was significantly higher post universal acceleration.
Dingman, Teuscher, Newton, & Kasmer, 2013	Comparative Analysis	State Math Standards from 42 states from pre-Common Core compared to CCSS Mathematics K-8	Data Collection: All K–8 standards in any strand were searched to identify those standards that addressed five broad emergent algebra categories. Data analysis: Identify algebra categories (e.g., functions) and particular algebra topics (e.g., slope) in the standards	Three general trends across the five algebra categories emerged when comparing the State Standards Analysis to CCSSM. First, there is a decrease in emphasis in Patterns standards across grades K–8. Second, there is a delayed emphasis on Functions, with this emphasis moved to grades 6–8. Third, there is an increased emphasis across grades K–8 on mathematical properties and relationships between operations standards.
Showalter, 2017	Nonparametric variant of	9,416 high school	Participants given	Analysis provided no evidence that course taking

Reference	Type	Sample	Data Collection	Results
	propensity score analysis	students in grade 10	questionnaire, and math and English assessments, then follow-up interviews two and four years later	in the algebra-calculus pipeline helped students to place out of postsecondary remedial mathematics classes.

Conclusion

Acceleration in mathematics has been a long, ongoing debate regarding when and how it should be done. Research is overdue for an update on policies and best practices regarding acceleration since the adoption of the Common Core State Standards (CCSS) in many states. The promotion of AP course enrollment also continues to be an ongoing debate. Some parties believe that AP course enrollment should continue to increase while others believe it should decline, and a greater focus should be placed on ensuring a strong foundation for coursework students will take once they actually attend college. Underlying all these debates is the impact on children and their developmental readiness to learn and be exposed to more advanced material.

CHAPTER THREE: METHODOLOGY

The purpose of this study was to investigate the difference in achievement on standardized assessments for AP mathematics students (female, male) who followed different mathematics pathways (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). This chapter includes the following sections: (a) Description of the Setting, Participants, and Sampling Procedures, (b) Research Questions, (c) Research Design, (d) Instrumentation, (e) Analyses, (f) Chapter Summary, (g) Ethics Statement.

Description of the Setting, Participants, and Sampling Procedures

Setting

This study was conducted in an urban district in the Northeast. The district was situated in a city with a population between 80,000 and 100,000 people that served 10,000 to 12,000 students (CSDE, 2019), approximately 3,000 of whom were at the high school level. This community's estimated median household income in 2017 was between $60,000 and $70,000 and there was a poverty rate between 10% and 15% (CSDE, 2019). There are more than 2,500 total industries in the town including construction, manufacturing, retail trade, health care and social assistance, accommodation and food services, and government (CSDE, 2019). This urban school district consisted of 19 public schools: 13 elementary schools serving grades pre-kindergarten through grade 5, 3 middle schools serving grades 6 through 8, 1 alternative middle school serving grades 6-8, 1 alternative high school serving grades 9 through 12, and 1 comprehensive high school serving grades 9 through 12. The diverse student population included 0.3% American Indian or Alaska Native, 5.2% Asian, 12.8% Black or African

American, 25.8% Hispanic or Latino, 0.1% Pacific Islander, 52.4% White, and 3.6% classified as two or more races (CSDE, 2019).

At the high school level, where the study took place, there were over 300 faculty members including general education and special education teachers, paraprofessionals, administrators, counselors, nurses, and other staff providing non-instructional services or support (CSDE, 2019). The sample population consisted of eleventh and twelfth grade students enrolled in AP mathematics courses during the 2018-2019 school year. At the time of the study there were 176 students in grade 11 and 12, enrolled in either AP Statistics or AP Calculus (AB or BC) and 9 students enrolled in both AP Statistics and AP Calculus courses simultaneously. The school adopted an open enrollment policy for their AP courses. Any student meeting the prerequisites was allowed to take AP classes regardless of whether they were accelerated in middle school. For AP Statistics, students must have completed algebra II but could enroll in AP Statistics concurrently with geometry. For AP Calculus (AB or BC), students must have completed pre-calculus, which has its own prerequisites including completion of algebra 1, algebra 2, and geometry.

Participants

The sample in this study was a sample of convenience, as all students were already enrolled in an AP mathematics course or courses when the study began. Some of the students could also be dual enrolled in an Early College Entrance (ECE) program as well. In this district the only difference between students only enrolled in AP and students enrolled in AP/ECE was that students enrolled in the ECE courses registered for the course with the local university and took an additional final exam provided by the local university. Students could earn college credit regardless of their AP score if they passed the class and the local exam. Prior to beginning the

research study, the researcher obtained consent from the Western Connecticut State University Institutional Review Board (IRB; see Appendix A). The assessment scores and mathematics course pathways students were enrolled in, beginning with seventh grade, were obtained from personnel at the school district's central office. This district does not have a specific gifted program for their students. The acceleration described in this study is purely related to mathematics. Students identified in the accelerated program in seventh grade remained grouped in eighth grade for algebra 1. When they entered high school, they were still grouped together on teams in ninth grade. However, once the students entered 10th grade, they could be placed in a math class with students in their grade level or other grade levels. Students could choose between an honors or college preparatory level for any of these classes. Specific grouping no longer applied after grade 9. Gender identification data were included with the data from central office and compared to student responses on the demographic survey. No disparities were found in student gender identification. Table 6 includes demographic summary data for the participants.

Table 6

Student Demographic Frequency Data

Group	Frequency	Percentage
Female		
Pathway 1		
AP Calculus	11	8.40
AP Stat and AP Calc	4	3.05
AP Statistics	19	14.50
Total	34	25.95
Pathway 2		
AP Calculus	6	4.58
AP Statistics	30	22.90
Total	36	27.48
Total Female	70	53.44
Male		
Pathway 1		
AP Calculus	14	10.69
AP Stat and AP Calc	2	1.53
AP Statistics	14	10.69
Total	30	22.90
Pathway 2		
AP Calculus	4	3.05
AP Stat and AP Calc	2	1.53
AP Statistics	25	19.08
Total	31	23.66
Total Male	61	46.56
Total	131	100.0

This study was used to compare assessment scores for students based on whether they began an accelerated mathematics pathway in seventh grade or entered an AP class having

completed the traditional mathematics sequence with no early acceleration. The accelerated course in grade 7 was a combination of seventh and eighth grade mathematics courses to be completed in one year. Typical course sequences can be found in Figure 2. Students who were in Pathway 1 did not have to double up any mathematics classes to reach A.P. Calculus. All students had the opportunity to reach A.P. Statistics by grade 12 without having to take two mathematics courses simultaneously.

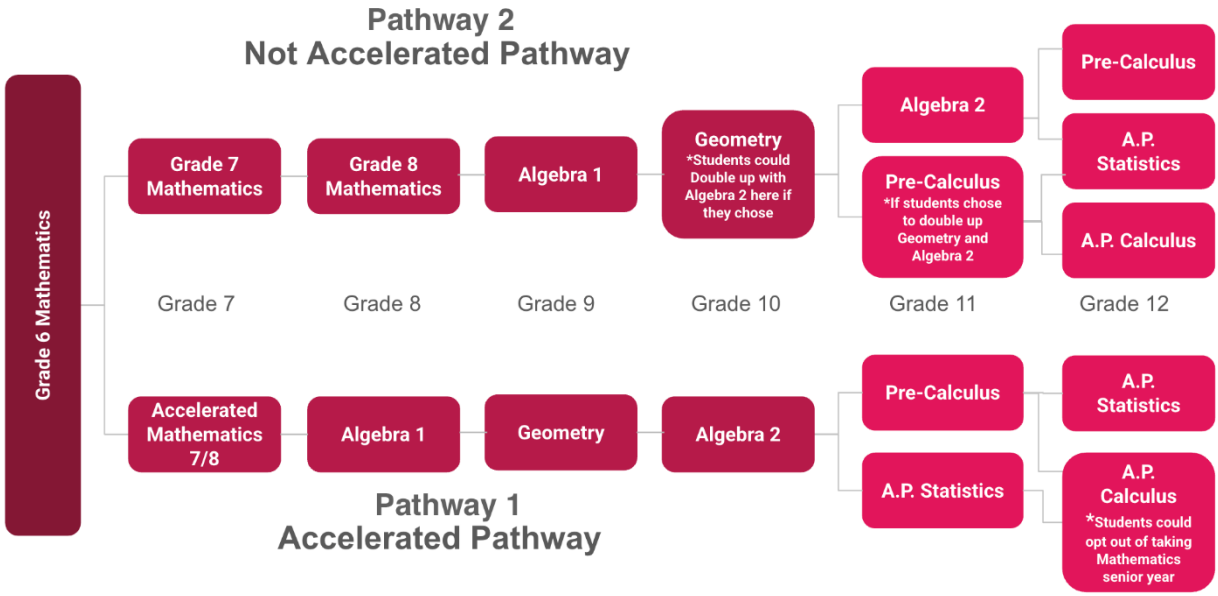

Figure 2. Typical Course Sequences

Following Pathway 1 did not impact any other course placement in subjects outside of mathematics. For students in Pathway 2, having to double up on courses at some point in their math pathway could have prevented them from taking other elective courses they may have preferred or additional AP classes in other subject areas. This is particularly true for students who wanted to take AP calculus, but not always the case for students who wanted to take AP statistics, since the highest prerequisite course for AP statistics was Algebra 2.

Research into the placement criteria for the students in this population revealed eleventh and twelfth graders involved in this study, who were attending middle school in the school

district, all took the same placement exam to determine eligibility for the accelerated seventh grade mathematics class. This placement exam was created by the school district based on researching success criteria for algebra readiness. The assessment included four parts; number fluency, rational numbers, algebraic concepts, and function application. The assessment was based on prerequisite skills from prior grade level mathematics standards as well as analytical thinking skills. The assessment was broken into four parts. All students took parts A and B, which assessed Number Fluency and Rational Numbers. There was a cut score that students had to obtain on parts A and B to take parts C and D, which were based on algebraic concepts and Function Applications. There was a second cut score for parts C and D that students had to meet in order to be eligible for accelerated placement. Prior to those years, the process had been more subjective, based on grades and teacher recommendation. Since those years, the district shifted to a combination of standardized testing scores, in conjunction with other observable student academic behaviors. Pathway 1 participants might not have accelerated at all in subsequent grade levels but may have completed AP statistics. Pathway 2 participants who still reached AP calculus by graduation doubled up on courses at some point in high school to be enrolled in calculus. There were six AP mathematics teachers who taught a total of nine AP mathematics courses including Statistics, Calculus AB, and Calculus BC. These courses included 176 students. Student scores were compared from the AP exam, SAT test, and STAR mathematics assessment. The researcher aimed to include all 176 students enrolled in AP mathematics courses across the AP mathematics classes. Table 7 and Table 8 indicate the demographics for those students with consent to be part of the study.

Table 7

Student Demographic Data by Gender for Each Course

Group	Female		Male		
	n	Percent of Females by Course	*n*	Percent of Males by Course	Total
AP Calculus	17	24.3	18	29.5	35
AP Stat and AP Calc	4	5.7	4	6.6	8
AP Statistics	49	70.0	39	63.9	88
Total	70	100.0	61	100.0	131

Note. Calc = Calculus; Stat = Statistics

Table 8

Student Demographic Data by Pathway for Each Course

Group	Pathway 1		Pathway 2		
	n	Percent of Females by Course	*n*	Percent of Males by Course	Total
AP Calculus	25	39.1	10	14.9	35
AP Stat and AP Calc	6	9.4	2	3.0	8
AP Statistics	33	51.6	55	82.1	88
Total	64	100.0	67	100.0	131

Note. Calc = Calculus; Stat = Statistics

The school district was an early adopter of Common Core State Standards (CCSS). The students in this study would have experienced mathematics classes following CCSS from at least fifth grade. At a minimum, the students would have had at least two full years of CCSS style mathematics prior to acceleration (https://www.thecorestandards.org/Math/).

Sampling Procedures

To begin the data collection process, the researcher met with all six of the teachers who were currently teaching at least one of the nine AP Mathematics class sections. There were six AP Statistics classes, two AP Calculus AB classes, and one AP Calculus BC class. All six teachers agreed to participate in the study. Following the receipt of teacher consent, the researcher provided teachers with a summary of the study, consent letters for parents of students,

as well as a student assent form and a demographic survey for students. Of the 176 students enrolled in an AP Statistics class and/or Calculus class, 131 students agreed to participate, as indicated in Tables 7 and 8. All data collection took place after the AP testing concluded.

Research Questions and Hypotheses

The following research questions were addressed in this study:

1. Is there a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female)?

   Non-Directional Hypothesis: There will be a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female).

2. Is there a significant difference in student achievement (STAR Assessment and SAT mathematics test) between mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female)?

   a. Is there a significant difference in student achievement (STAR Assessment and SAT mathematics test) between mathematics path (Pathway 1: students who were in an

accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine)?

b. Is there a significant difference in student achievement (STAR Assessment and SAT mathematics test) between males and females?

c. Is there a significant interaction for student achievement (STAR Assessment and SAT mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender (male, female)?

Non-Directional Hypothesis: There will be a significant difference in student achievement between pathway and gender.

Description of Research Design

The research study was a quantitative study involving nonexperimental research. Both research questions one and two were assessed through a causal comparative approach. In this type of research, "researchers seek to identify cause-and-effect relationships by forming groups of individuals in whom the independent variable is present or absent" (Gall, Gall, & Borg, 2003, p. 296). The study focused on the impact mathematics placement, beginning in middle school, had on student standardized assessment scores in high school. The students in the study were all enrolled in at least one AP mathematics course, but did not all follow the same trajectory to arrive there. One of the independent variables in this study was mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). Gender (male/female) was also an independent variable. The data from these groups were then

analyzed to determine "whether the groups differ on the dependent variable" (Gall et al, 2003, p. 296). All students who enrolled in at least one AP mathematics class in grades 11 or 12 were invited to participate in the study and asked to complete a demographic survey. Through the demographic information, the researcher was able to determine groups. Course enrollment by group was assessed as well as standardized assessment scores.

Description of the Instruments

Data were collected using the following instruments (a) student demographic survey, (b) AP Mathematics Scores, (c) STAR Mathematics Assessment, and (d) SAT Mathematics scores.

Student Demographic Survey

Students completed a demographic survey at the beginning of the study that included gender, current course enrollment, whether they were enrolled in an accelerated mathematics course in seventh grade, current grade level, grade level they first entered the school district, attendance in their mathematics class, overall feelings about mathematics, and homework completion rate. The purpose of the survey was to collect general data about the students to describe the sample.

AP Mathematics Exam

This exam, in conjunction with the course syllabus, undergoes a series of reviews by college professors, as well as analysis of piloted results prior to being administered to AP students (The College Board, 2016). The goal of the exam is to ensure that students taking AP courses in high school truly experience a college level course and gain a deep enough understanding of the subject to receive college credit for it. The AP Calculus AB and AP Calculus BC exams have the same structure for the assessment. There are two sections on each, a multiple-choice section and a free response section. Within each of the two sections there is a

calculator required portion and a calculator not permitted section. There are 30 multiple choice sections where a calculator is not permitted and 60 minutes are allotted for this section. The calculator required multiple choice sections consists of 15 questions with 45 minutes to complete it. The free response section includes two questions to be completed in 30 minutes with a calculator. It includes four questions to be completed in 60 minutes without a calculator. The AP Statistics Exam also has two sections (The College Board, 2020). It includes 40 multiple choice questions with 90 minutes provided to complete it. The free response section includes five questions to be completed in 65 minutes as well as an investigative task to be completed in 25 minutes. A graphing calculator is permitted throughout the assessment. These assessments are both administered in May.

Many placement validity studies have been done that analyze college level course outcomes in comparison to AP scores. The first study to examine the validity and reliability of AP exams was done in 1998 by Morgan and Ramist (Patterson, Ewing, & College Board, 2013). The researchers compared performance in next level courses of students who had taken AP courses, earning a 3, 4, or 5 on the exam, and students who had not taken an AP course but had taken an equivalent introductory level course in a college setting. Findings for this study indicated that AP students scored better than their non-AP peers on all subsequent courses up to a fifth level of the course where applicable (Patterson, Ewing, & College Board, 2013). A more recent study, with 53 participating colleges, evaluated the success of AP students in postsecondary courses. In all cases, some more significantly than others, the AP students outperformed the non-AP students in second level courses (Patterson, Ewing, & College Board, 2013). These studies validate the use of AP exam scores being used for college level course placement.

STAR Mathematics Assessment

The STAR assessment consists of 24 problems and is typically administered in 30 minutes. It is split into three types of items; number concepts, computation, and a mix of other mathematical concepts. Validity of the STAR assessment is demonstrated in two forms. When the assessment is administered in grades one through six, there is concurrent validity scoring ranging from $r = 0.64$ to $r = 0.75$ with an overall average of $r = 0.73$. When the assessment is administered in grades seven through 12, there is concurrent validity scoring of $r = 0.56$ to $r = 0.74$ with an overall average of $r = 0.71$. There is predictive validity when the assessment is administered in grades one through six with scores between $r = 0.55$ and $r = 0.74$ with an overall average of $r = 0.72$ and for grades seven through twelve, scores between $r = 0.65$ and $r = 0.77$ with an overall average of $r = 0.74$ (Renaissance Learning, 2024). There are also multiple forms of reliability regarding the STAR Mathematics Assessment. The split-half method was used. All measures of reliability ranged from $r = 0.89$ to $r = 0.94$.

SAT Suite of Assessments

The SAT Suite of Assessments includes the SAT, PSAT/NMSQT, PSAT 10, and PSAT 8/9 (The College Board, 2017). The assessment that was analyzed in this study was the SAT. The assessment tests for scholastic aptitude at different grade levels. The SAT Mathematics is a 58 question, 80-minute test, and is scored on a scale of 200-800 (The College Board, 2017). Many colleges require students to submit their SAT or similar assessment scores as part of the application process. Results of both methods are consistent for the test as a whole as well as for the different sections of the assessment. It was found that reliability scores varied between males and females, with values being higher for males, but little to no difference in reliability was

found between different racial and ethnic groups. The College Board conducted a predictive validity study after beginning the new SAT (The College Board, 2017). First year students in 15 four-year institutions made up the sample and it was found that the new SAT was as good of a predictor of college success as the old SAT. Another analysis was used to examine the percent of students meeting the benchmark scores on any of the SAT Suite of Assessments tests (The College Board, 2017). The researchers found that of all the students who met the benchmark on the first test, at least 80% of them met the benchmark score on the second test as well (The College Board, 2017). This provides consistency and validity for the SAT assessment.

Data Collection Procedures and Timeline

The data collection was conducted over the course of two months. In June the researcher met with AP teachers and distributed and collected the demographic survey. In July, the researcher obtained test score data from the district central office upon the release of AP scores.

Permission was obtained from the Superintendent (Appendix B), Principal (Appendix C) and participating teachers (Appendix D). All of the 176 students enrolled in AP mathematics courses were invited to participate in the study. The researcher provided an overview of the study to the students and an opt-out letter of consent was distributed to parents (Appendix E) to briefly explain the study and ask for permission to have their child participate. Instead of asking each parent/guardian to consent to having their child participate in the study, it is the school district's procedure to ask parents/guardians to indicate if they do not want their child to participate in a particular study when it involves normal educational practices. An assent form (Appendix F) was provided to students requesting that they confirm their interest and willingness to participate in the study.

The data collection procedures in Table 9 were followed according to the proposed timeline.

Table 9

Timeline

Anticipated Dates	Description of Procedure
May 2019	Superintendent, Principal, and Teacher permission obtained to conduct the study. Opt-out forms sent home to students' parents/guardians; assent forms distributed to students and collected
June 2019	Demographic Survey taken by students
July 2019	Assessment data obtained
July – August 2019	Data Analysis
September 2019 - March 2025	Analysis Results Reported

Description and Justification of the Analyses

Research question one. Is there a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female)?

This quantitative research question was used to determine if course enrollment in middle school had an effect on student outcomes for those who ultimately enrolled in an AP course. The variables were categorical for this question. A chi-square test was used to analyze the data for

significant differences in the scores of students taking AP courses based on pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), gender (male, female), and AP mathematics scores (a score of 1, 2 or a score of 3-5). A chi-square test is appropriate to use when analyzing this type of data because "a chi-square statistic is used to test the difference between the predicted and the observed relationships" of data representing non-parametric measurement scales (Meyers, Gamst, & Guarino., 2006, p. 608). The prediction was that there would be a significant difference in expected and observed student performance (AP score) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female). This predication was based on the assumption that accelerated students had already been tested in middle school in order to gain entry into the seventh grade accelerated class and would maintain that advantage over time.

Research question two. Is there a significant difference in student achievement (STAR Assessment, SAT Mathematics test) between mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender (male, female)?

Scores were obtained for two standardized assessments and compared based on course enrollment in middle school and gender. A 2x2 multivariate analysis of variance (MANOVA) was used to analyze the data for student achievement (STAR Assessment, SAT Mathematics test) between mathematics pathways (Pathway 1: students who were in an accelerated

mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender (male, female). The student achievement data (STAR Assessment, SAT Mathematics test) are interval in nature and the mathematical pathways and gender are each categorical variables. A 2x2 MANOVA is appropriate to use when analyzing both gender and pathway as MANOVAs are used when "assessing the effects of one dichotomous (two-group) independent variable on two or more quantitative dependent variables" (Meyers et al., 2006, p. 365).

Summary of Chapter Three

This chapter delineated the methods used by the researcher to conduct the study. Quantitative data collection and analyses were described. The quantitative data collected were mathematics course enrollment from seventh grade through grades 11 or 12, AP course selections, gender, and three types of mathematics assessment scores (STAR, SAT, and AP mathematics assessments).

Ethics Statement

Approval was sought and obtained from the Institutional Review Board (IRB) of Western Connecticut State University to conduct the study. Permission to participate in this research was obtained from the district's superintendent, the school principal, and all participating teachers. Opt-out forms were sent home with students to inform their parents/guardians about the study and to indicate if they did not want their student to participate in the study. All students were informed about the study and invited to participate. Assent was obtained from all participating students. To assure confidentiality, each participant was assigned a coded identification number. These coded data are available to researchers related to the study for the purposes of data verification, and analysis. All data and information were collected by the researcher and

stored at a different location to protect school, teacher, and student privacy. Aggregated data results were made available to all interested parties upon request.

CHAPTER FOUR: DATA ANALYSIS

The purpose of this study was to investigate the impact of two different course pathways (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) for students who completed one AP mathematics course by grade 11 or 12 of high school. Student success in this case was gauged through AP, SAT, and STAR scores. Chapter four addresses the statistical analyses and results in relation to the research questions in this study. This chapter includes seven sections: (a) research questions and hypotheses, (b) description of the data, (c) demographic results, (d) analysis of outliers, (e) descriptive statistics, (f) quantitative data analysis, results, and interpretation of the hypothesis for research question one, and (g) quantitative data analysis, results, and interpretation of the hypothesis for research question two.

Research Questions and Hypotheses

The following research questions were addressed in this study:

1. Is there a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female)?

   Non-Directional Hypothesis: There will be a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female).

2. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female)?
    a. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine)?
    b. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between males and females?
    c. Is there a significant interaction for student achievement (STAR Assessment and SAT Mathematics test) between mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender (male, female)?

    Non-Directional Hypothesis: There will be a significant difference in student achievement between pathway and gender.

Description of the Data

Both categorical and numeric data were collected in this study. The variables are described in Table 10. Demographic data was also collected from students.

Table 10

Dependent and Independent Variables Based on Research Question

Research Question	Dependent Variable	Independent Variable
One		Mathematics Pathway (Pathway 1, Pathway 2) Gender (female, male), AP mathematics score (not passing = 1-2; passing = 3-5)
Two	SAT scores, STAR scores	Mathematics Pathway (Pathway 1, Pathway 2), Gender (female, male)

Students completed a demographic survey (Appendix H). The questions were designed to gain information regarding when the students entered the school district, how many absences they had, how they would describe their feelings about mathematics, and whether they always do homework. The following tables and figures summarize the resulting data.

Table 11

Number of Absences in the Current School Year

Pathway	Zero	1 to 4	5 to 9	10 or more	Overall Frequency
Pathway 1	1	29	24	4	58
Pathway 2	1	36	22	5	64
Total	2	65	46	9	122

Table 12

Grade Level when Entering the School District

Pathway	Elementary	Middle School	High School	Overall Frequency
Pathway 1	49	3	6	58
Pathway 2	59	3	2	64
Total	108	6	8	122

Table 13

Self-Reported Feelings About Mathematics

Pathway	I don't like math	Math is okay – I'm indifferent	I like math	I love math	Overall Frequency
Pathway 1	3	8	31	16	58
Pathway 2	3	17	35	9	64
Total	6	25	66	25	122

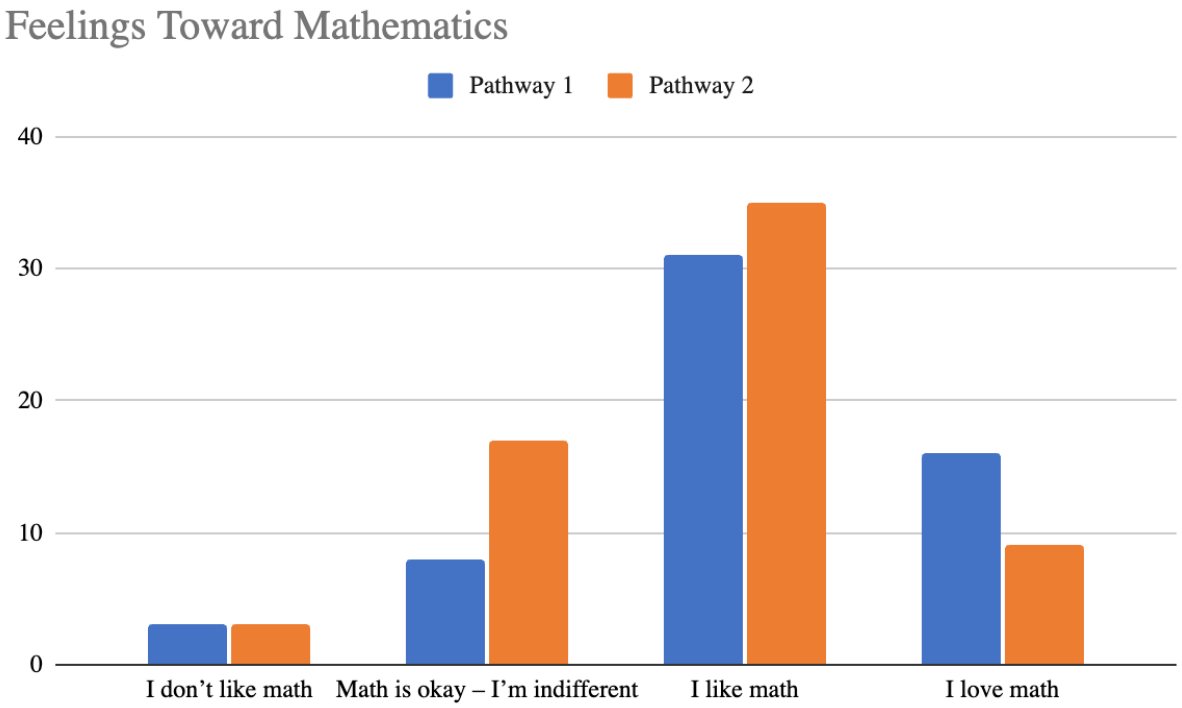

Figure 3. Feelings Toward Mathematics

Table 14

Self-Reported Homework Completion Rates

Pathway	Occasionally	Most of the time	Yes, all of the time	Overall Frequency
Pathway 1	3	22	33	58
Pathway 2	4	38	22	64
Total	7	60	55	122

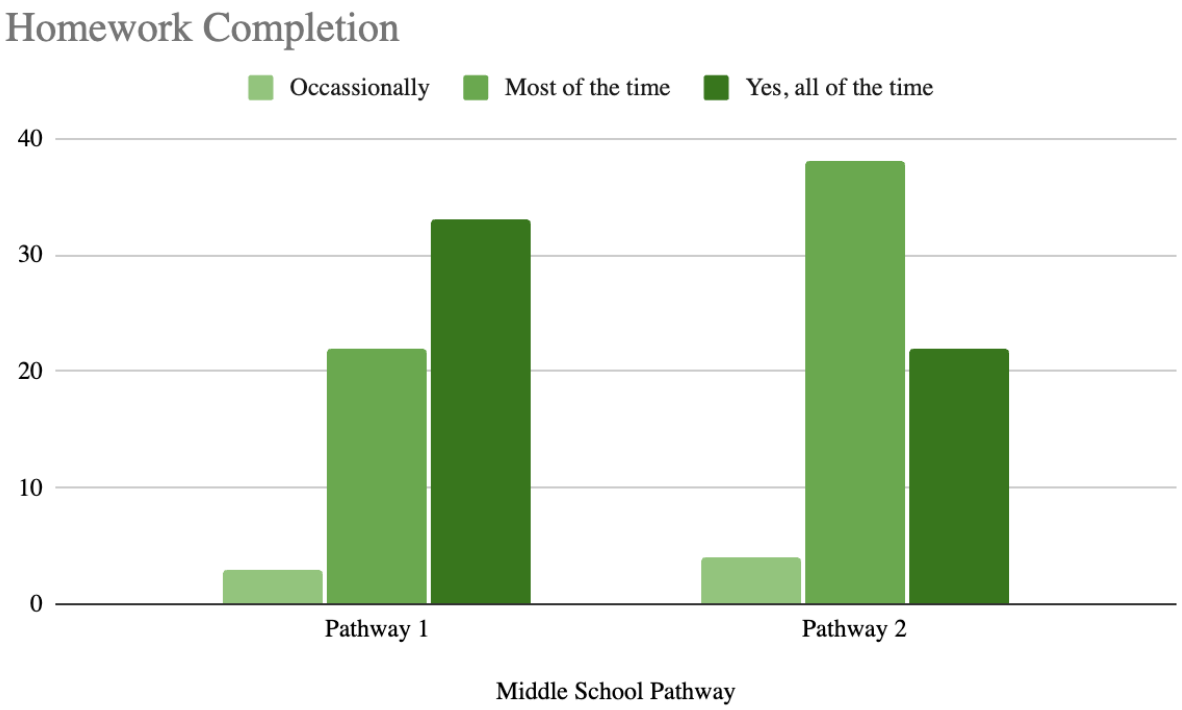

Figure 4. Self-Reported Homework Completion Rates

The number of absences during the current school year was relatively similar between students who were in Pathway 1 (*n* = 58) and students who were in Pathway 2 (*n* = 64). There were only eight students who reported not entering the school district until high school. Of those students (*n* = 8), 75% of them reported being in an accelerated middle school pathway. The majority of students (*n* = 122), 88.5%, reported that they had been in the school district since

elementary school. The students reported how they felt about mathematics by choosing from a scale of ratings including: “I don’t like math,” “math is okay – I’m indifferent,” “I like math,” and “I love math.” As seen in Figure 3, there was a similar breakdown of students who reported they don’t like mathematics as there was to those who reported they like mathematics. There was a distinct difference in those who responded that they were indifferent and those who said they love mathematics. The preponderance of students responding that they were indifferent about mathematics was from Pathway 2 and the preponderance of students responding with I love math came from the students who were in Pathway 1. A similar outcome occurred when students self-reported their homework completion rates. The number of students who reported that they “occasionally” did their homework was nearly the same in both groups. When comparing the “most of the time” verses “all of the time” responses, the preponderance of students reporting they completed their homework most of the time came from the students who were in Pathway 2 and those reporting that they completed their homework all of the time came from the students who were in Pathway 1.

Research Question One

Categorical data were collected from all participants enrolled in AP mathematics courses. The AP test score data (Figure 5) was analyzed through two categories (score of 1,2, score of 3-5). The data included historical enrollment information about each participant's mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). Specific course enrollments were retrieved per student for each year from the 2013-2014 school year through the 2018-2019 school year. Gender identity was also compared (male, female). Table 16 delineates the student enrollment frequencies based on

middle school pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), gender (female, male), and year (11, 12). Tables 13-15 show the score frequencies for students enrolled in each course separately.

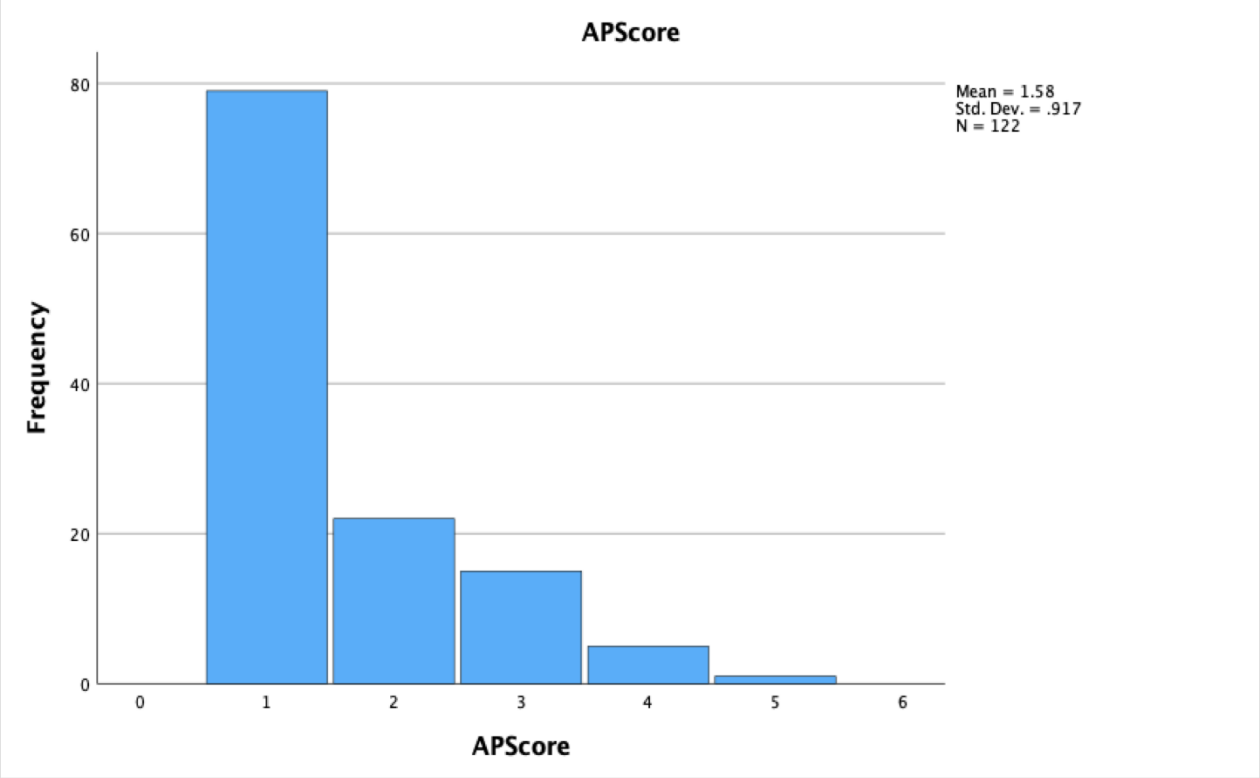

Figure 5. AP Score Frequencies

Table 15

AP Score Frequencies – AP STAT ONLY

		AP Score of 1-2 (Not Passing)	AP Score of 3-5 (Passing)
Pathway 1	Female	9	8
	Male	8	5
Pathway 2	Female	30	2
	Male	25	1

Table 16

AP Score Frequencies – AP CALC ONLY

		AP Score of 1 or 2 (Not Passing)	AP Score of 3, 4, or 5 (Passing)
Pathway 1	Female	7	4
	Male	12	1
Pathway 2	Female	5	0
	Male	5	0

Table 17

Chi Square Frequencies – AP STAT and AP CALC (n=8)

		AP Calculus		AP Statistics	
		Score of 1 or 2 (Not Passing)	Score of 3, 4, or 5 (Passing)	Score of 1 or 2 (Not Passing)	Score of 3, 4, or 5 (Passing)
Pathway 1	Female	2	2	1	3
	Male	1	1	1	1
Pathway 2	Female	0	0	0	0
	Male	2	0	2	0

Table 18

Course Enrollment Frequencies

			Specific Course Enrollment Frequency					
Pathway	Gender	Year	AP Stat	AP Calc AB	AP Calc BC	STAT & AB	STAT & BC	Total
Pathway 1	Female	11	12	1	0	1	1	15
		12	5	6	3	1	1	17
	Male	11	12	1	0	0	1	13
		12	2	12	0	1	0	15
	Total		31	20	3	3	3	60
Pathway 2	Female	11	5	0	0	0	0	5
		12	27	6	0	0	0	33
	Male	11	6	0	0	0	0	6
		12	20	5	0	1	1	27
	Total		58	11	0	1	1	71
Grand Total			89	31	3	4	4	131

The students enrolled in AP courses that had been in Pathway 1 had a relatively similar spread between grade 11 and 12. For students that were in Pathway 2, it was more likely that twelfth graders would be enrolled in an AP course than eleventh graders.

Research Question Two

Quantitative data were collected for research question two that included mathematics achievement scores from SAT and STAR mathematics assessments. The independent variables for this research question were mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female). The dependent variables were student achievement as measured by the and SAT mathematics assessment.

Data Coding and Entry

Demographic data were collected through a student survey and then entered into a spreadsheet. Student enrollment and test score data were provided from the central office of the school district where the study took place. These data were provided through spreadsheets with student unique IDs. One spreadsheet was then created by the researcher to combine all student information. The researcher utilized multiple VLookUp calculations to combine all data into one spreadsheet.

After the data were combined, participants were assigned a random identifier number and all other identifying information was removed. A code book was created to ensure student data was organized and could be easily referenced (Table 19). The researcher initially used a spreadsheet to calculate the Chi-Square statistic and then the researcher entered all data into SPSS v. 28 (IBM Corp, 2021) to run additional analyses. The demographic information included a randomly assigned ID number, the current enrolled grade level, gender, middle school acceleration status, and the AP course(s) in which each participant was enrolled. The remainder of the codebook (Table 20) contained numeric data in the form of standardized test score results. These included SAT, STAR, and AP mathematics scores.

Table 19

SPSS Codebook of Student Demographic Variables

Code Name	Label	Type of SPSS Field	Values
IDrandom	Student ID for study	Numeric	1-131
JRorSR	Student Enrolled Grade	Numeric	0 = grade 11 1 = grade 12
GenderCode	Male or Female	Numeric	0 = male 1 = female
MSstatus	Accelerated or Not Accelerated	Numeric	0 = Not Accelerated (Pathway 2) 1 = Accelerated (Pathway 1)
APCourse	AP Calculus AB, AP Calculus BC, AP Statistics	Numeric	0 = AP Statistics only 1 = AP Calculus AB or BC only 2 = Both AP Calculus and AP Statistics

Note. Enrollment in a calculus course, either AB or BC, was considered as a single code or group.

Table 20

SPSS Codebook of Independent and Dependent Variables

Code Name	Label	Type of SPSS Field	Values
APScoreSTAT	AP Statistics Score	Numeric	1-5
APscoreCALCAB	AP Calculus AB Score	Numeric	1-5
APscoreCALCBC	AP Calculus BC Score	Numeric	1-5
APscoresCALCany	AP Calculus Score Combined Data	Numeric	1-5
SAT	SAT Math Score	Numeric	200-800
STAR_SS	STAR Math Scaled Score	Numeric	0-1400
STAR_PR	STAR Math Percentile Rank	Numeric	1-99

Data Screening and Cleaning

All data were entered into SPSS and initial descriptive analyses were completed (Table 21). Kolmogorov-Smirnov and Shapiro-Wilk values were calculated to ensure the data met criteria for all analyses. The skewness and kurtosis values were notably out of range for STAR scores regarding males as the z-scores were well over 3.29 (Field, 2009). This is also evident

through the tests of normality (Table 22), where the STAR scores for males did not meet the .001 significance level (Meyers et al., 2006).

Table 21

Initial Descriptive Statistics (N=131)

Assessment	Gender			Statistic	Std. Error	Z Score
STAR Scale Score	male	Mean		932.95	17.318	
		95% Confidence Interval for Mean	Lower Bound	898.31		
			Upper Bound	967.59		
		5% Trimmed Mean		940.10		
		Median		926.00		
		Variance		18294.548		
		Std. Deviation		135.257		
		Minimum		268		
		Maximum		1244		
		Range		976		
		Interquartile Range		95		
		Skewness		-1.762	0.306	-5.753
		Kurtosis		9.372	0.604	15.520
	female	Mean		917.93	10.638	
		95% Confidence Interval for Mean	Lower Bound	896.71		
			Upper Bound	939.15		
		5% Trimmed Mean		918.98		
		Median		916.50		
		Variance		7921.517		
		Std. Deviation		89.003		
		Minimum		689		
		Maximum		1123		
		Range		434		
		Interquartile Range		96		
		Skewness		-0.119	0.287	-0.415

Assessment	Gender			Statistic	Std. Error	Z Score
		Kurtosis		0.680	0.566	1.201
SAT	male	Mean		574.75	10.683	
		95% Confidence Interval for Mean	Lower Bound	553.38		
			Upper Bound	596.12		
		5% Trimmed Mean		572.72		
		Median		570.00		
		Variance		6962.022		
		Std. Deviation		83.439		
		Minimum		410		
		Maximum		800		
		Range		390		
		Interquartile Range		105		
		Skewness		0.341	0.306	1.112
		Kurtosis		0.177	0.604	0.294
	female	Mean		569.86	9.645	
		95% Confidence Interval for Mean	Lower Bound	550.62		
			Upper Bound	589.10		
		5% Trimmed Mean		570.24		
		Median		570.00		
		Variance		6511.573		
		Std. Deviation		80.694		
		Minimum		360		
		Maximum		760		
		Range		400		
		Interquartile Range		103		
		Skewness		-0.049	0.287	-0.171
		Kurtosis		0.202	0.566	0.356

Table 22

Initial Tests of Normality by Gender (N=131)

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
STAR Scale Score	Male	0.195	61	0.000	0.826	61	0.000
	Female	0.078	70	.200*	0.973	70	0.138
SAT Score	Male	0.098	61	.200*	0.983	61	0.543
	Female	0.054	70	.200*	0.991	70	0.895

All the variables in the initial screening met normality criterion of +/- 1 or probability level of $p < .001$ (Meyers et al., 2006) with the exception of the STAR scale scores for males. The STAR scale scores for males were not acceptable because they did not meet the recommended criterion for kurtosis (Table 21) with a value of 9.372 and K-S and S-W probability level (Table 22) with $p = 0.000$. Of the initial 131 participants, 8 were removed due to lack of independence between AP courses (5, 6, 28, 48, 52, 103, 117, and 122). These eight participants were enrolled in both AP calculus as well as AP statistics. This would violate the fact that "each person or case can be counted only once, they cannot appear in more than one category or group" (Pallant, 2016, p. 215). Being enrolled in either AB or BC calculus was the same category for the purposes of this study. No students were simultaneously enrolled in AB and BC calculus, so independence was not violated by combining these two courses into an overarching AP calculus category. Exploratory descriptive statistics were run again without the eight students. Regardless of their removal, the results were similar in that the skewness and kurtosis values were notably out of range for males on the STAR assessment (Table 23) and the tests of normality (Table 24) for STAR scores for males did not meet the .001 significance level.

Table 23

Descriptive Statistics (N=123)

Assessment	Gender			Statistic	Std. Error	Z Score
STAR Scale Score	male	Mean		928.98	18.261	
		95% Confidence Interval for Mean	Lower Bound	892.40		
			Upper Bound	965.56		
		5% Trimmed Mean		936.21		
		Median		924.00		
		Variance		19007.375		
		Std. Deviation		137.867		
		Minimum		268		
		Maximum		1244		
		Range		976		
		Interquartile Range		89		
		Skewness		-1.734	0.316	-5.482
		Kurtosis		9.088	0.623	14.584
	female	Mean		909.74	10.333	
		95% Confidence Interval for Mean	Lower Bound	889.11		
			Upper Bound	930.38		
		5% Trimmed Mean		910.83		
		Median		910.00		
		Variance		7046.440		
		Std. Deviation		83.943		
		Minimum		689		
		Maximum		1122		
		Range		433		
		Interquartile Range		84		
		Skewness		-0.231	0.295	-0.783
		Kurtosis		0.976	0.582	1.676
SAT	male	Mean		569.47	10.938	
			Lower Bound	547.56		

Assessment	Gender			Statistic	Std. Error	Z Score
		95% Confidence Interval for Mean	Upper Bound	591.38		
		5% Trimmed Mean		566.77		
		Median		570.00		
		Variance		6819.361		
		Std. Deviation		82.579		
		Minimum		410		
		Maximum		800		
		Range		390		
		Interquartile Range		100		
		Skewness		0.434	0.316	1.373
		Kurtosis		0.429	0.623	0.689
	female	Mean		562.88	9.211	
		95% Confidence Interval for Mean	Lower Bound	544.48		
			Upper Bound	581.27		
		5% Trimmed Mean		564.21		
		Median		565.00		
		Variance		5599.277		
		Std. Deviation		74.828		
		Minimum		360		
		Maximum		730		
		Range		370		
		Interquartile Range		93		
		Skewness		-0.292	0.295	-0.989
		Kurtosis		0.248	0.582	0.427

Table 24

Tests of Normality by Gender (N=123)

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
STAR Scale Score	Male	0.198	57	0.000	0.826	57	0.000
	Female	0.084	66	.200*	0.970	66	0.104
SAT Score	Male	0.098	57	.200*	0.978	57	0.393
	Female	0.060	66	.200*	0.989	66	0.809

All the variables in the second screening met normality with the exception of the STAR scale scores for males. The STAR scale scores for males were not acceptable because they did not meet the criterion for kurtosis of +/- 1 (Table 23) with a value of 9.088 (Table 24) with p = 0.000, based on an acceptable probability level of $p < .001$. In addition, the *z-kurtosis* = 14.584, well above the acceptable level of 3.29 as recommended by Field (2009). After reviewing exploratory descriptive statistics, one more participant (112) was removed due to being an extreme outlier on the STAR assessment (see Figure 6) scoring over three standard deviations below the mean for STAR mathematics.

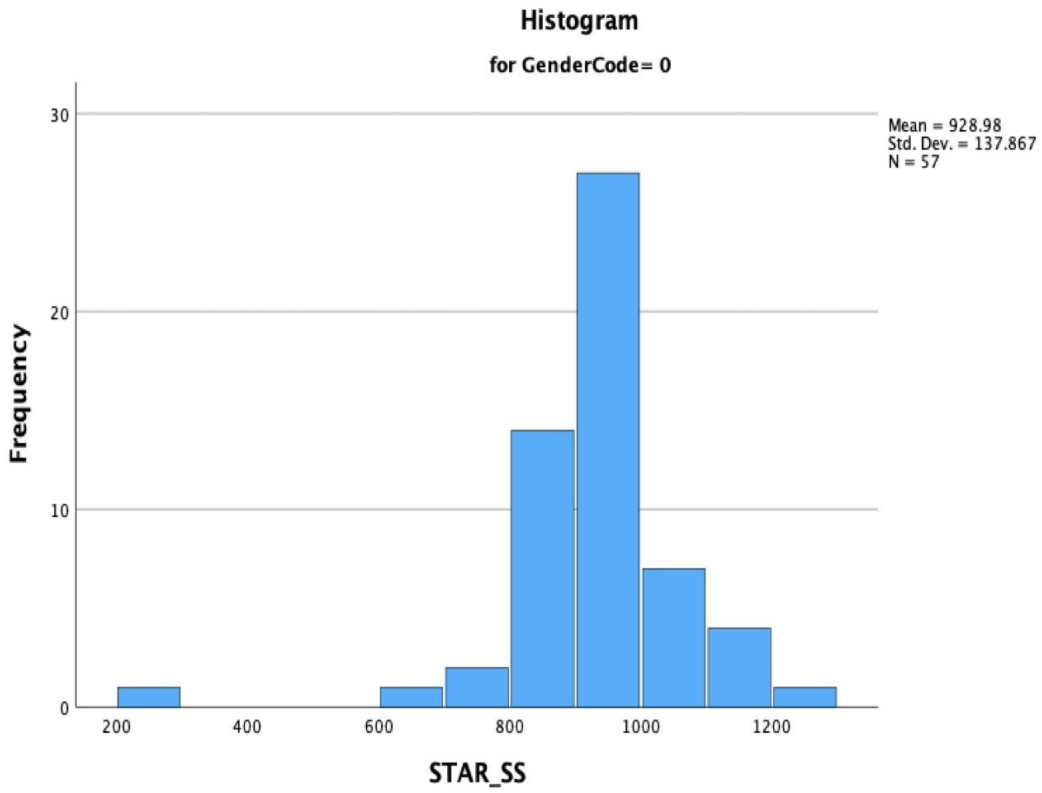

Figure 6. Male STAR Mathematics Scores with Outlier.

After removing the final participant, the descriptive statistics (Table 25) were conducted one final time and STAR scores and SAT scores both fell within an acceptable range, $z < 3.29$, according to Andy Field (Field, 2009). Additionally, the tests of normality for the Kolmogorov-Smirnov statistic and Shapiro-Wilk statistic were not significant at $p < .001$ (Meyers et al., 2006), (Table 26).

Table 25

Descriptive Statistics (N=122)

Assessment	Gender Code			Statistic	Std. Error	Z Score
STAR Scale Score	male	Mean		940.79	14.185	
		95% Confidence Interval for Mean	Lower Bound	912.36		
			Upper Bound	969.21		
		5% Trimmed Mean		940.12		
		Median		924.50		
		Variance		11267.517		
		Std. Deviation		106.149		
		Minimum		637		
		Maximum		1244		
		Range		607		
		Interquartile Range		91		
		Skewness		0.334	0.319	1.047
		Kurtosis		1.676	0.628	2.668
	female	Mean		909.74	10.333	
		95% Confidence Interval for Mean	Lower Bound	889.11		
			Upper Bound	930.38		
		5% Trimmed Mean		910.83		
		Median		910.00		
		Variance		7046.440		
		Std. Deviation		83.943		
		Minimum		689		
		Maximum		1122		
		Range		433		
		Interquartile Range		84		
		Skewness		-0.231	0.295	-0.783
		Kurtosis		0.976	0.582	1.676
SAT	male	Mean		572.14	10.798	

	95% Confidence Interval for Mean	Lower Bound	550.50		
		Upper Bound	593.78		
	5% Trimmed Mean		569.52		
	Median		570.00		
	Variance		6529.870		
	Std. Deviation		80.808		
	Minimum		410		
	Maximum		800		
	Range		390		
	Interquartile Range		100		
	Skewness		0.489	0.319	1.532
	Kurtosis		0.517	0.628	0.823
female	Mean		562.88	9.211	
	95% Confidence Interval for Mean	Lower Bound	544.48		
		Upper Bound	581.27		
	5% Trimmed Mean		564.21		
	Median		565.00		
	Variance		5599.277		
	Std. Deviation		74.828		
	Minimum		360		
	Maximum		730		
	Range		370		
	Interquartile Range		93		
	Skewness		-0.292	0.295	-0.989
	Kurtosis		0.248	0.582	0.427

Table 26

Tests of Normality by Gender (N=122)

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
STAR Scale Score	Male	0.146	56	.004	0.934	56	0.004
	Female	0.084	66	.200*	0.970	66	0.104
SAT Score	Male	0.104	56	.199	0.977	56	0.376
	Female	0.060	66	.200*	0.989	66	0.809

After removal of nine participants, all variables met normality. The STAR scale scores for males met the kurtosis criterion (Table 25) with a value of $z = 2.668$. The STAR scale scores also met normality (Table 26) with $p = 0.004$.

Demographic Results

Students were grouped by gender and pathway. In the initial data, there were 60 students who were accelerated in grade 7 and 71 students who were not accelerated in grade 7 ($n = 131$). Of those students, 70 were female and 61 were male. Taking out the eight participants who were enrolled in both AP Statistics and AP Calculus and the one extreme outlier, there were 54 students remaining in Pathway 1 and 68 students in Pathway 2 ($n = 122$). Of those students, 66 were female and 56 were male.

Table 27

Gender Identity and Pathway of Participants

Group	Female *n* (%)	Male *n* (%)	Total *n* (%)
Pathway 1	28 (42.4)	26 (46.4)	54 (44.3)
Pathway 2	38 (57.6)	30 (53.6)	68 (55.7)
Total	66 (100.0)	56 (100.0)	122 (100.0)

Analysis of Outliers

After the one participant was eliminated from the study due to being an extreme outlier for their STAR score, the Kurtosis value for Male Star Scores went from 9.088 with a *z*-score of 14.584 to 1.676 with a *z*-score of 2.668.

Results

Research Question One

This question addressed if there was a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female) This quantitative research question was used to determine if course enrollment in middle school predicted student scores on the AP assessments. The data were all categorical for this question. A chi-square test was used to analyze the data for significant differences in AP scores based on pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female). A chi-square test is appropriate to use when analyzing this type of data because "a chi-square statistic is used to test the difference between the predicted and the observed relationships" (Meyers et al., 2006, p. 608).

Descriptive Statistics

The frequencies for students grouped by pathway and gender identity are shown in Table 28. While there were more female students than male students, the range of group totals was

similar. The students were approximately even based on gender in Pathway 1. The spread for Pathway 2 students was wider, but still relatively close.

Table 28

Frequencies for Students Grouped by Pathway and Gender Identity Per Course

Pathway		Females	Males	Total
Pathway 1	AP Statistics	17	13	30
	AP Calculus	11	13	24
Total		28	26	54
Pathway 2	AP Statistics	32	25	57
	AP Calculus	6	5	11
Total		38	30	68
Grand Total		66	56	122

Male students in Pathway 1 were split with half enrolled in AP Statistics and the other half enrolled in AP Calculus. More female students from Pathway 1 were enrolled in AP Statistics than AP Calculus. Students in Pathway 2 were more likely to enroll in AP Statistics than AP Calculus regardless of whether their gender identity was male or female.

Student AP assessment scores were categorized into two groups. The scores of 1 and 2 were combined to represent students not passing the AP exam and the scores of 3-5 were combined to represent students passing the AP exam. These were further reported by gender and pathway.

Table 29

Frequencies of Students with Specific AP Scores by Gender and Mathematics Pathway

		Pathway		
		Pathway 1 (algebra 1 in grade 8)	Pathway 2 (algebra 1 in grade 9)	Total
AP Score (1-2)	Females	16	35	51
	Males	20	30	50
	Total	36	65	101
AP Score (3-5)	Females	12	2	14
	Males	6	1	7
	Total	18	3	21
Grand Total		54	68	122

Since there was only one female student and two male students total who passed any AP test from Pathway 2, it was decided to collapse gender for the purposes of this study (Table 30).

Table 30

Frequencies of Students with Specific AP Scores by Mathematics Pathway Collapsed by Gender

	Pathway		
	Pathway 1 (algebra 1 in grade 8)	Pathway 2 (algebra 1 in grade 9)	Total
AP Score (1-2)	36	65	101
AP Score (3-5)	18	3	21
Grand Total	54	68	122

Box plots are provided to show the comparisons between male and female participants as well as Pathway 1 and Pathway 2 participants for both the STAR and SAT test.

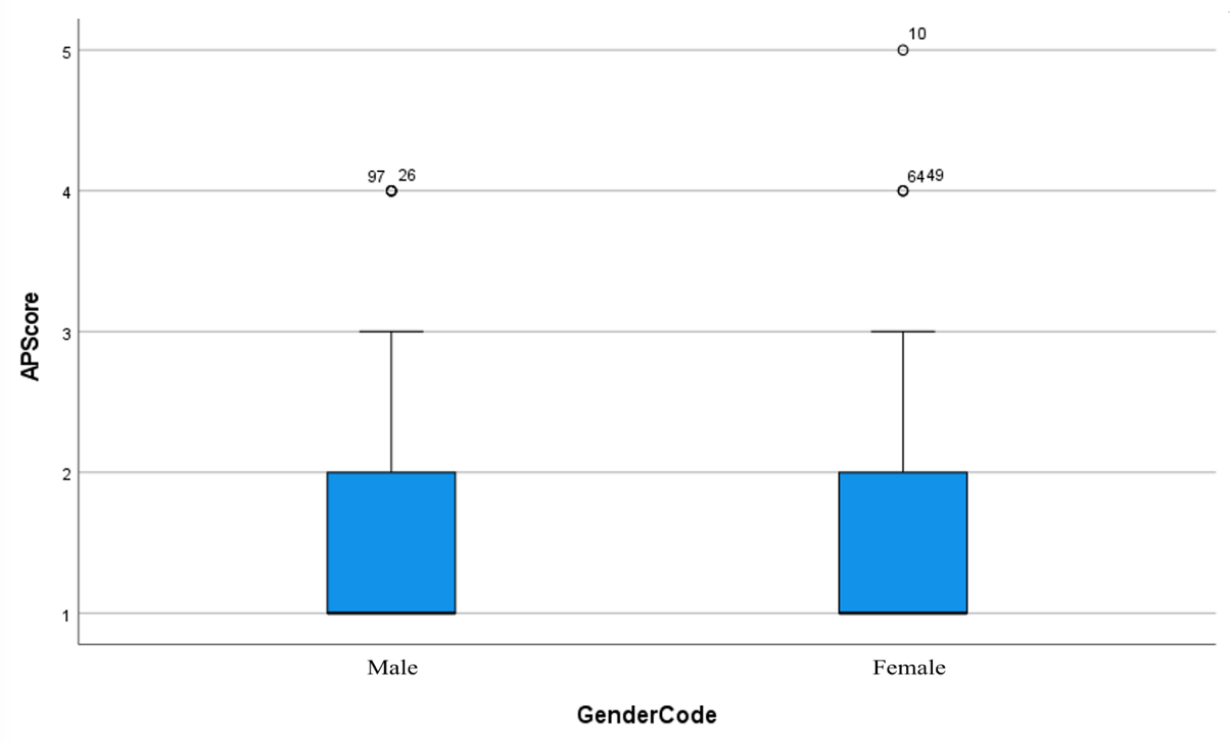

Figure 7. AP Score Box and Whiskers by Gender

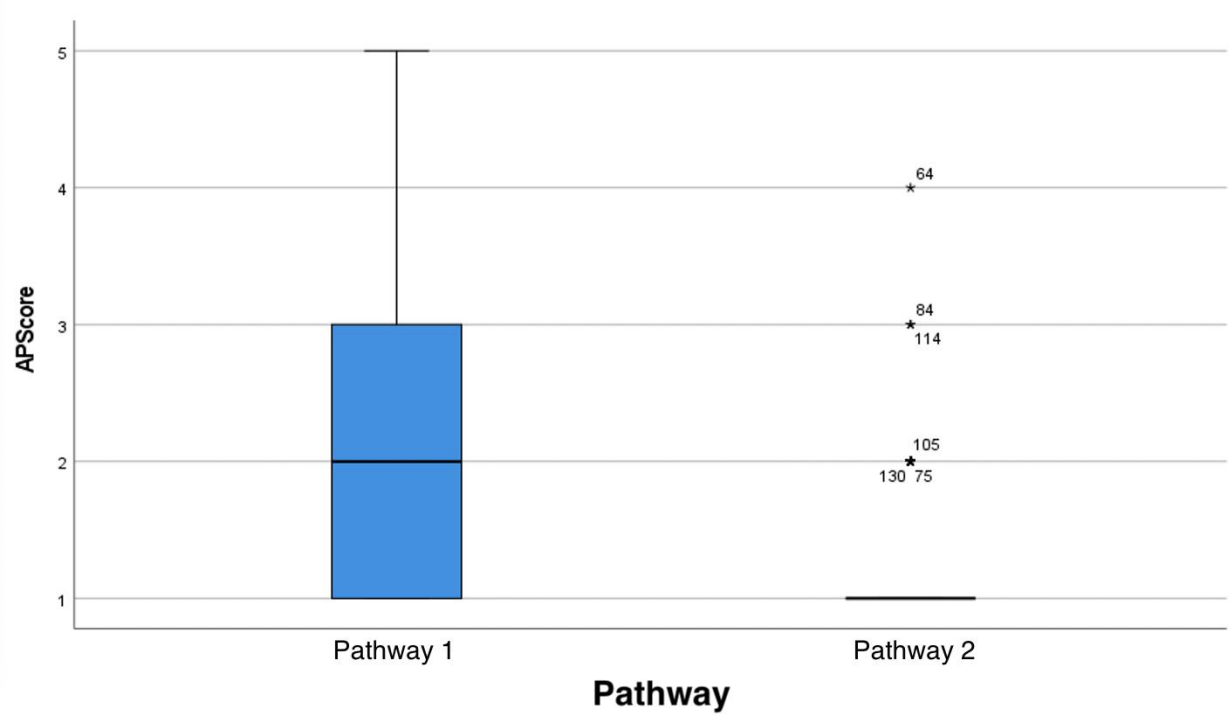

Figure 8. AP Score Box and Whiskers by Pathway.

When viewed by gender, the Box Plots showed similar results for males and females. The box plots for middle school status displayed very different scores for students in Pathway 1 and Pathway 2 (see Figure 7 and Figure 8).

Assumptions

A chi-square test requires that all cells have an expected frequency greater than 5 (Pallant, 2016). The data for each cell in this chi-square does not violate this assumption.

Table 31

Chi Square Observed and Expected Values

	Chi square	Pathway		
		Pathway 1 (algebra 1 in grade 8)	Pathway 2 (algebra 1 in grade 9)	Total
Observed	AP Score (1-2)	36.00	65.00	101
	AP Score (3-5)	18.00	3.00	21
	Grand Total	54.00	68.00	122
Expected	AP Score (1-2)	44.70	56.30	101
	AP Score (3-5)	9.30	11.70	21

Results

A chi-square test for independence indicated significant association between AP scores and pathway is indicated in Table 32 and the effect size is displayed in Table 34.

Table 32

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	17.667[a]	1	<.001		
Continuity Correction	15.696	1	<.001		
Likelihood Ratio	18.722	1	<.001		
Fisher's Exact Test				<.001	<.001
Linear-by-Linear Association	17.522	1	<.001		
N of Valid Cases	122				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.30.

Table 33

Chi Square Crosstabulation with Residuals

			Fail	Pass	Total
Pathway	Pathway 1	Count	36.0	18.0	54.0
		Expected Count	44.7	9.3	54.0
		Residual	-8.7	8.7	
		Standardized Residual	-1.3	2.9	
		Adjusted Residual	-4.2	4.2	
	Pathway 2	Count	65.0	3.0	68.0
		Expected Count	56.3	11.7	68.0
		Residual	8.7	-8.7	
		Standardized Residual	1.2	-2.5	
		Adjusted Residual	4.2	-4.2	
Total		Count	101.0	21.0	122.0
		Expected Count	101.0	21.0	

Table 34

Chi-Square Symmetric Measures (n = 122)

		Value	Approximate Significance
Nominal by Nominal	Phi	.381	<.001
	Cramer's V	.381	<.001
N of Valid Cases		122	

There was a significant difference in expected and observed student achievement scores in AP courses between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). The results were $\chi 2$ (1, n = 122) = 17.667, $p < .001$, *phi* = .381 (Pallant, 2016, p. 222). The adjusted residuals (Table 33) were greater than ± 2 (± 4.2) meaning that the middle school pathway was a major contributor to the chi square. Students who were enrolled in Pathway 1 scored significantly higher than those who were in Pathway 2. A Bonferroni adjustment was unnecessary here because different test data were used for each research question.

Research Question Two

A 2x2 multivariate analysis of variance (MANOVA) was used to analyze the data for student achievement (STAR and SAT mathematics tests) between mathematics pathways (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female). Each dependent variable was interval in nature and the independent variables of mathematical pathways and gender identity were categorical.

Descriptive Statistics

Frequencies were calculated for all data. Histograms of SAT scores for all participants are included in Figure 9 and histograms for STAR scores for all participants are included in Figure 12. Box plots are provided to show the comparisons between male and female participants as well as pathways for both the STAR and SAT test.

Assumptions

The initial design of this study used a MANOVA. The assumptions for MANOVA include independence, sample size, multivariate normality, outliers, linearity, and homogeneity of covariance matrices (Pallant, 2016, Field, 2009).

Normality. The STAR scores and SAT scores were analyzed using descriptive statistics and ultimately met skewness and kurtosis measures. The SAT score frequencies had a normal distribution. The overall spread is shown in Figure 9. The box plots for gender identity and pathway are also included in Figures 10 and 11.

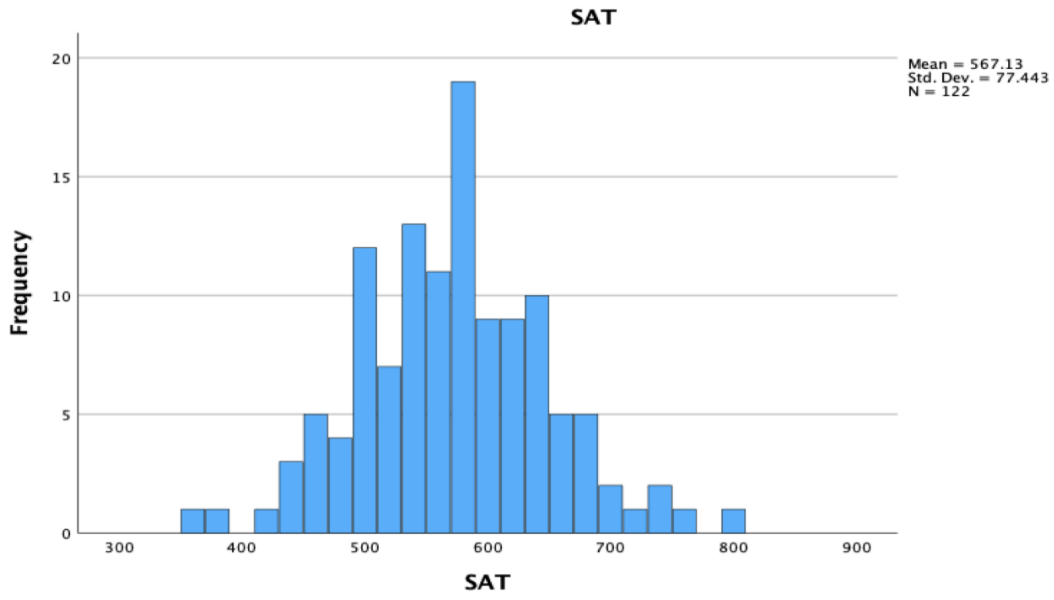

Figure 9. SAT Score Frequencies

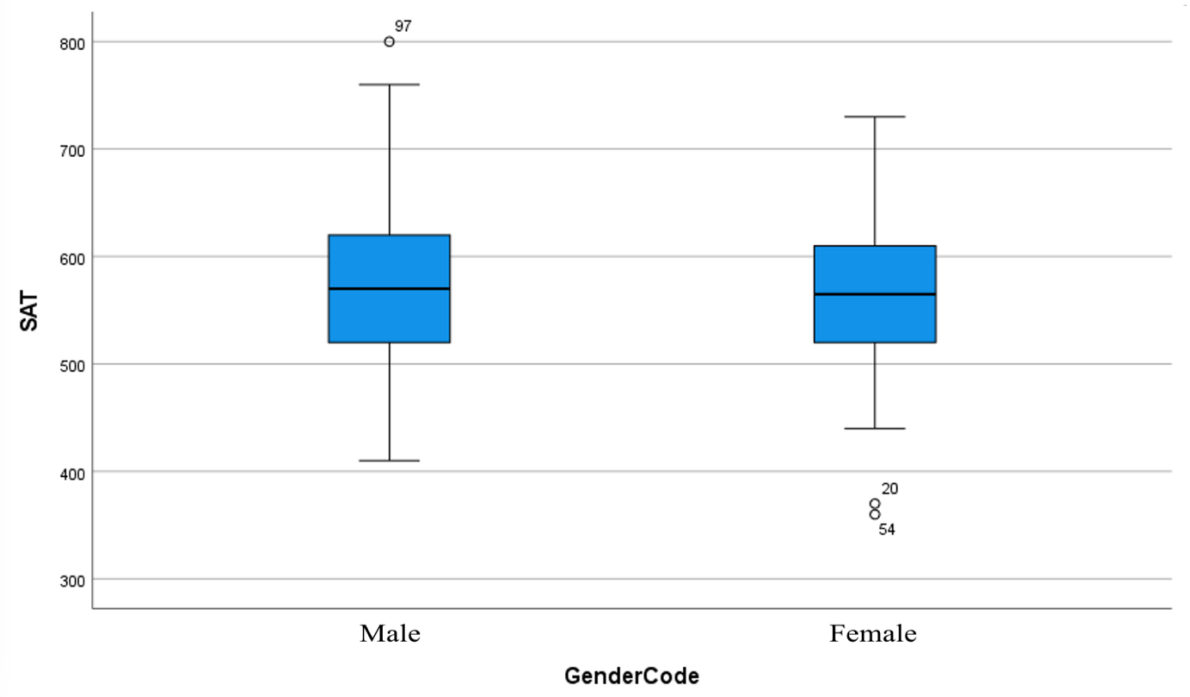

Figure 10. SAT Score Box and Whiskers by Gender

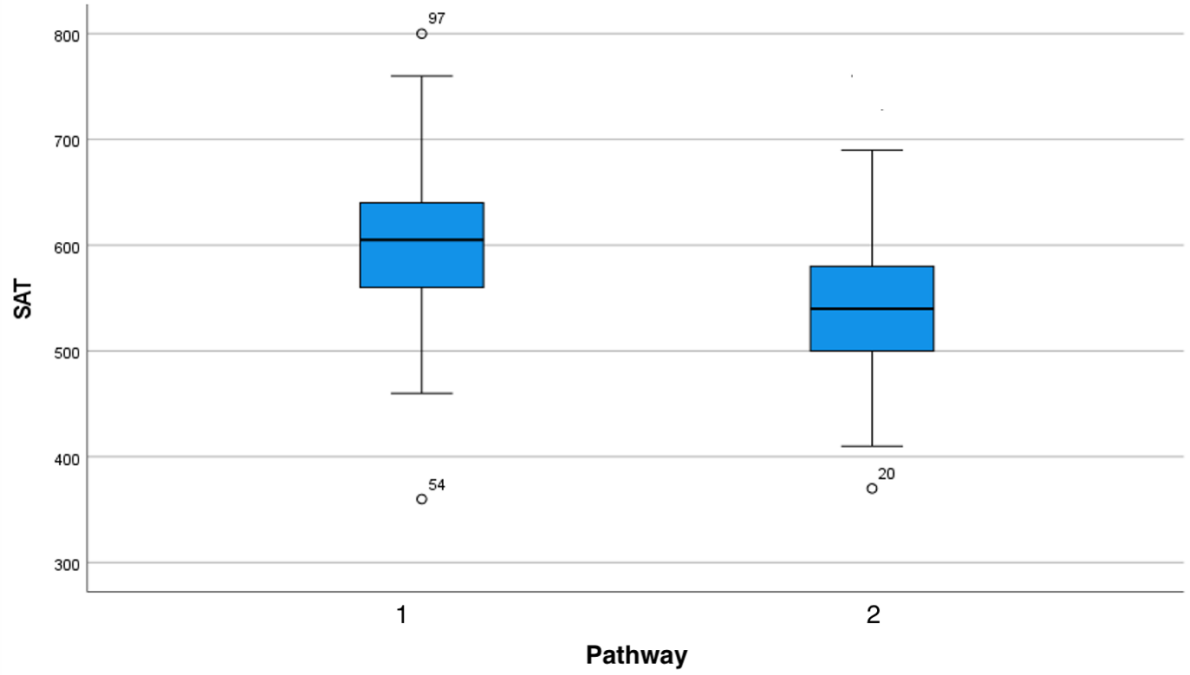

Figure 11. SAT Score Box and Whiskers by Pathway

The STAR score frequencies are shown in Figure 12. They are followed by the frequencies of Pathway 1 participants and Pathway 2 students in Figures 13 and 14. The box plot comparisons for pathway and gender are also shown in Figures 15 and 16.

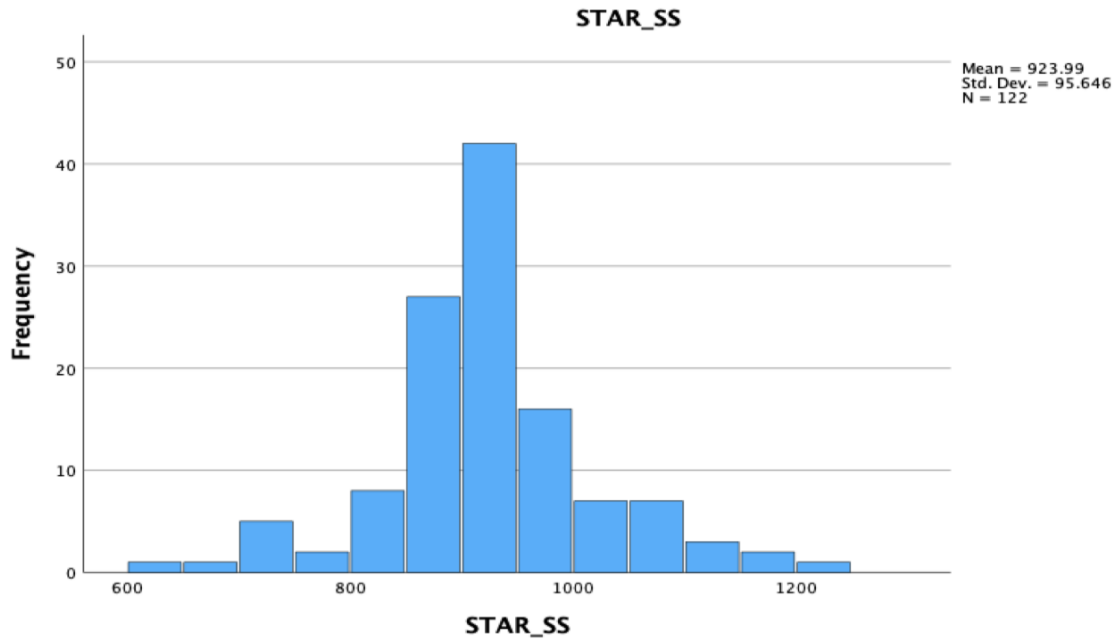

Figure 12. STAR Score Frequencies Overall

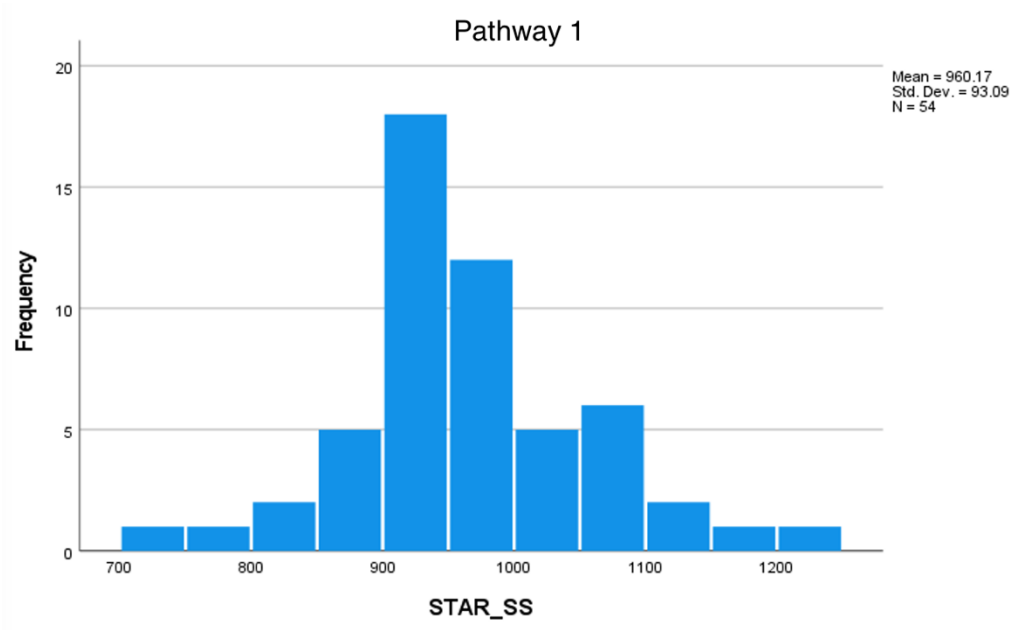

Figure 13. STAR Score Frequencies for Pathway 1 Students

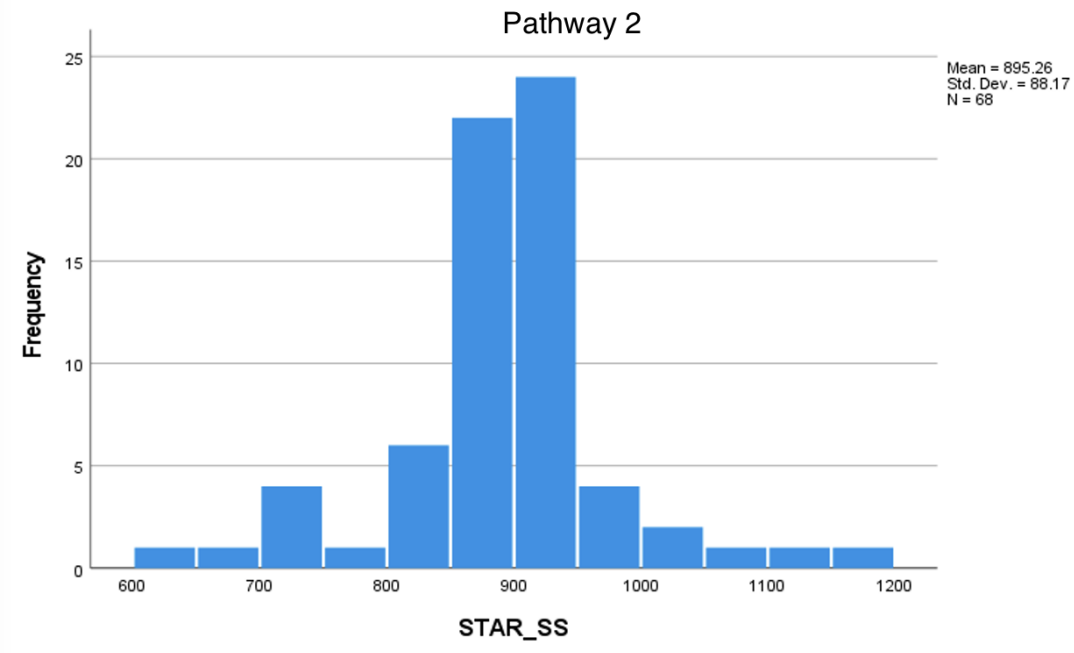

Figure 14. STAR Score Frequencies for Pathway 2 Students

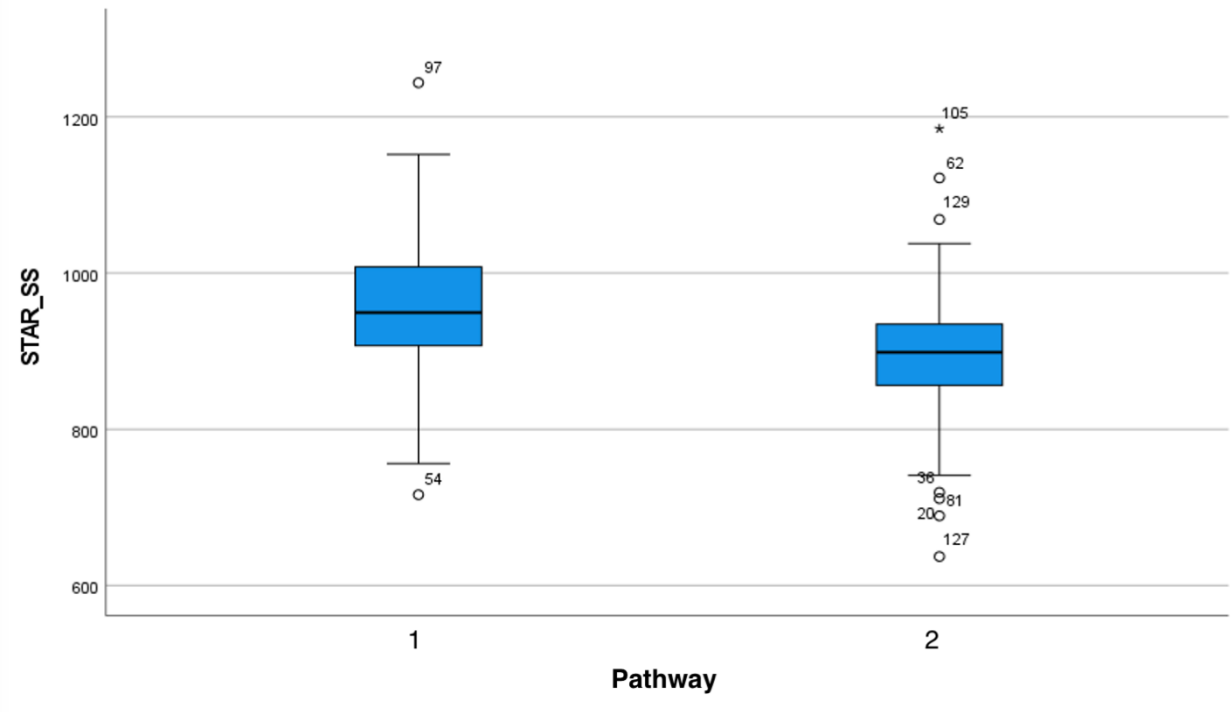

Figure 15. STAR Score Box and Whiskers by Pathway

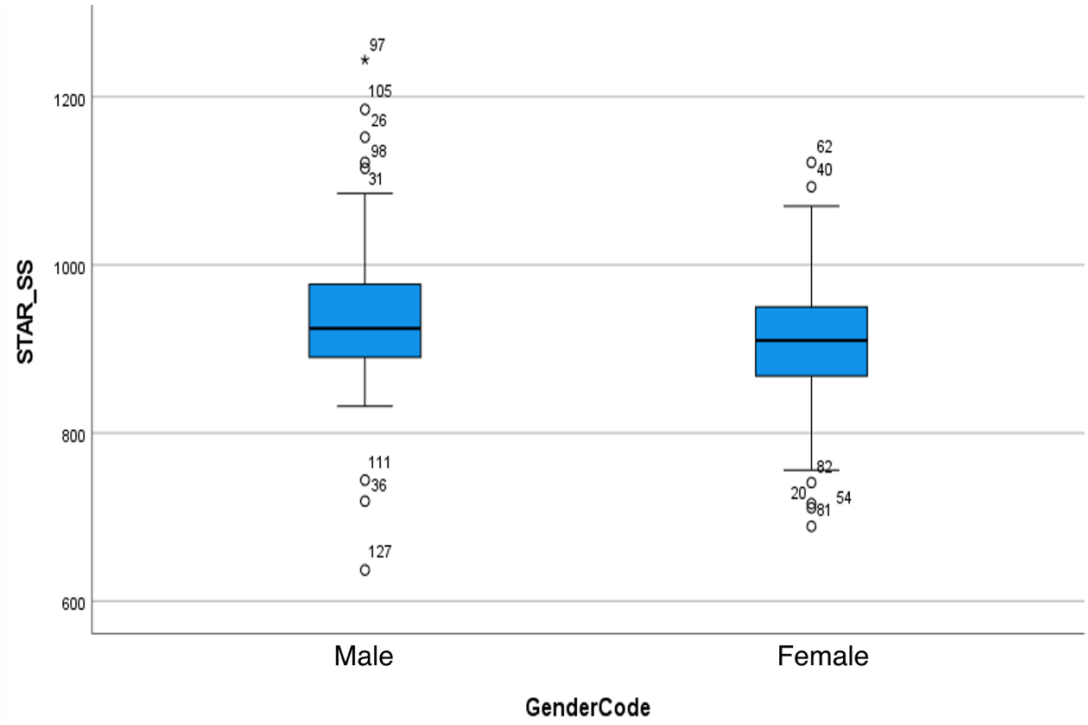

Figure 16. STAR Score Box and Whiskers by Gender

There was an abundance of STAR scores in the 800-1000 range for males that caused a higher kurtosis value. When comparing the scores based on gender, there is not as much variation as there is when comparing the scores by middle school status. While males had a higher mean STAR score (m = 940.79) compared to females (m = 909.74), they also had a greater standard deviation (SD = 106.149) than females (SD = 83.943). The sample size for males (n = 56) was smaller than females (n = 66).

Independence. Independence was met after the eight initial students were removed during the data cleaning. The students were removed because they were enrolled in both AP statistics and an AP calculus class.

Sample size. The sample size for a MANOVA requires that there are "more cases in each cell than you have dependent variables" (Pallant, 2016, p. 291). There was a total of eight cells in this study. There were two levels in each of the two independent variables: male/female

and Pathway 1/Pathway 2. There were two dependent variables in the form of standardized assessments for each of the independent variables. The reported data included scores for all students for both assessments.

Table 35

Frequencies for Students Grouped by Pathway and Gender Identity

Assessment		Pathway 1	Pathway 2	Total
STAR	Male	26	30	56
	Female	28	38	66
Total		54	68	122
SAT	Male	26	30	56
	Female	28	38	66
Total		54	68	122

Outliers. Not all outliers need to be removed in a MANOVA as long as they are not too extreme and the sample size is large enough (Pallant, 2016). The one outlier in this study was removed because it was more than three standard deviations below the mean for males on STAR. The remaining 121 scores on the STAR assessment ranged from 637 to 1185. There were no extreme outliers for females on STAR or SATs for either males or females.

Linearity. This assumption "refers to the presence of a straight-line relationship between each pair of your dependent variables" (Pallant, 2016, p. 294). The SAT scores and STAR scores were used to create a scatterplot and formed a positive linear correlation as indicated in Figure 17.

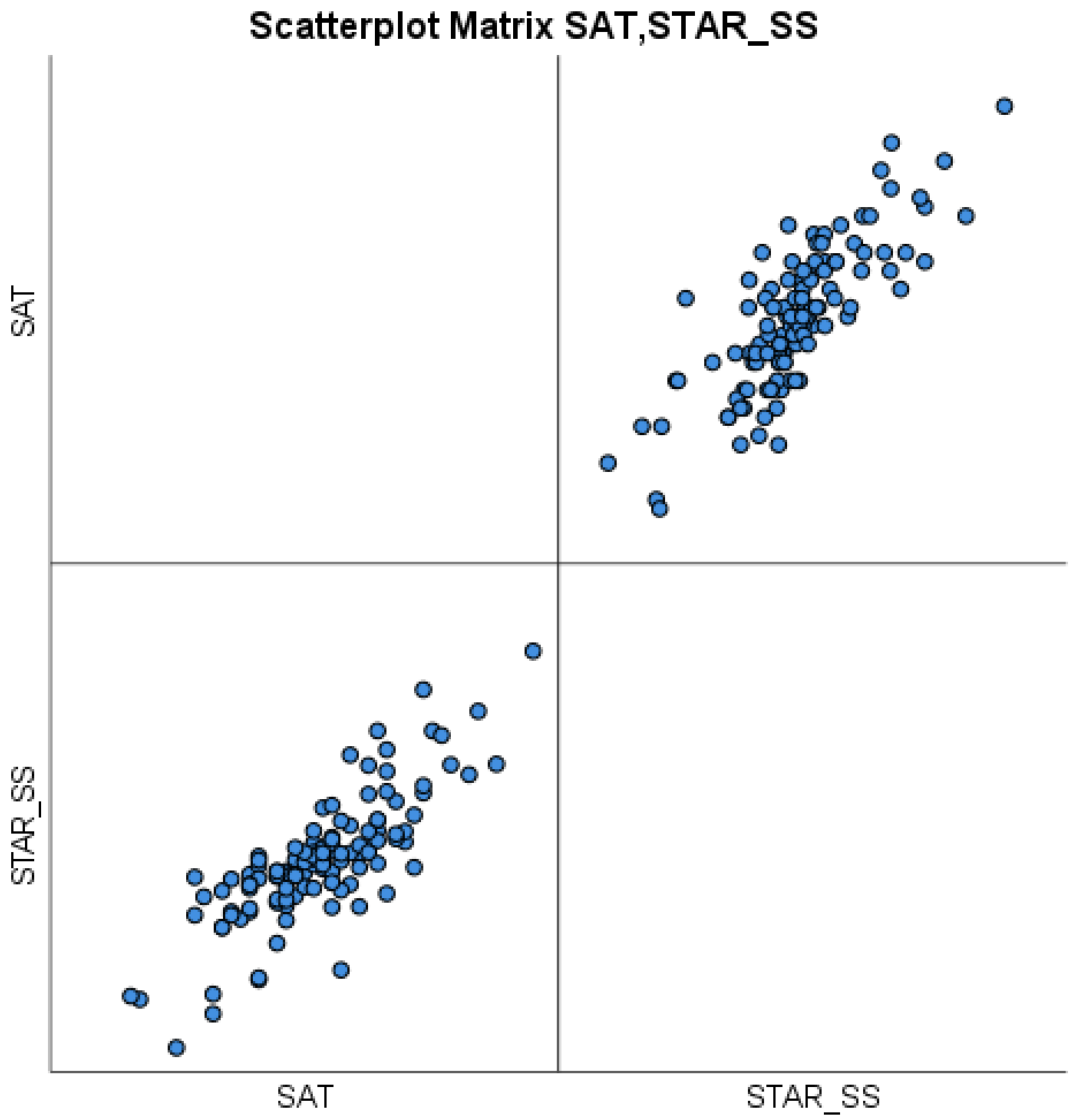

Figure 17. Scatterplot for SAT and STAR scores.

Homogeneity of covariance. The assumption for homogeneity of variance was addressed through the Box's M test (Table 36) as well as Levene's test (Table 37). The significance value for Box's M was $p < .679$. Since this value is larger than .001, the assumption was not violated. In the Levene's test, the significance values were all greater than $p \leq .05$ and therefore did not violate the assumption of homogeneity of variance.

Table 36

Box's Test of Equality of Covariance

Box's M	6.815
F	0.733
df 1	9.000
df 2	121626.857
Significance	0.679

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

Table 37

Levene's Test of Equality or Error Variances for SAT

		Levene Statistic	*df*1	*df*2	Sig.
SAT	Based on Mean	0.415	3	118	0.743
	Based on Median	0.310	3	118	0.818
	Based on Median and with adjusted *df*	0.310	3	109.931	0.818
	Based on trimmed mean	0.375	3	118	0.771
STAR_SS	Based on Mean	0.722	3	118	0.541
	Based on Median	0.460	3	118	0.711
	Based on Median and with adjusted *df*	0.460	3	109.457	0.711
	Based on trimmed mean	0.627	3	118	0.599

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Results

A two-way MANOVA was conducted to investigate the impact of gender and middle school placement on the SAT and STAR assessments. The independent variables were gender (male, female) and pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). Two dependent variables were used: SAT and STAR. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, and homogeneity of variance matrices, with no serious violations noted.

The MANOVA results based on Wilks' Lambda are indicated in Table 38. A follow-up analysis included a comparison of means for each group (Table 39 and Table 40).

Table 38

MANOVA Results for Differences in Gender Identity and Pathway With Respect to SAT and STAR Scores

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.991	6379.176	2	117	<.001	.991
	Wilks' Lambda	.009	6379.176	2	117	<.001	.991
	Hotelling's Trace	109.046	6379.176	2	117	<.001	.991
	Roy's Largest Root	109.046	6379.176	2	117	<.001	.991
Math Pathway	Pillai's Trace	.138	9.354	2	117	<.001	.138
	Wilks' Lambda	.862	9.354	2	117	<.001	.138
	Hotelling's Trace	.160	9.354	2	117	<.001	.138
	Roy's Largest Root	.160	9.354	2	117	<.001	.138
Gender	Pillai's Trace	.045	2.740	2	117	.069	.045
	Wilks' Lambda	.955	2.740	2	117	.069	.045
	Hotelling's Trace	.047	2.740	2	117	.069	.045
	Roy's Largest Root	.047	2.740	2	117	.069	.045
Math Pathway * Gender	Pillai's Trace	.017	1.003	2	117	.370	.017
	Wilks' Lambda	.983	1.003	2	117	.370	.017
	Hotelling's Trace	.017	1.003	2	117	.370	.017
	Roy's Largest Root	.017	1.003	2	117	.370	.017

Table 39

Means and Standard Deviations by Gender for SAT and STAR Mathematics Scores

		SAT	STAR
Male	Mean	572.14	940.79
	N	56.00	56.00
	Standard Deviation	80.808	106.149
Females	Mean	562.88	909.74
	N	66.00	66.00
	Standard Deviation	74.828	83.943
Grand Total	Mean	567.13	923.99
	N	122.00	122.00
	Standard Deviation	77.443	95.646

Table 40

Means and Standard Deviations by Middle School Pathway for SAT and STAR Mathematics Scores

		SAT	STAR
Pathway 1	Mean	598.52	960.17
	N	54.00	54.00
	Standard Deviation	78.87	93.09
Pathway 2	Mean	542.21	895.26
	N	68.00	68.00
	Standard Deviation	66.978	88.17
Grand Total	Mean	567.13	923.99
	N	122.00	122.00
	Standard Deviation	77.443	95.646

Table 41

Tests of Between Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	SAT	97089.583[a]	3	32363.194	6.075	0.001	0.134
	STAR_SS	159535.669[b]	3	53178.556	6.624	0.000	0.144
Intercept	SAT	38926259.499	1	38926259.499	7307.115	0.000	0.984
	STAR_SS	103085225.218	1	103085225.218	12839.527	0.000	0.991
Gender	SAT	1578.234	1	1578.234	0.296	0.587	0.003
	STAR_SS	27420.877	1	27420.877	3.415	0.067	0.028
Math Pathway	SAT	94388.506	1	94388.506	17.718	0.000	0.131
	STAR_SS	126138.360	1	126138.360	15.711	0.000	0.117
Gender * Math Pathway	SAT	153.542	1	153.542	0.029	0.865	0.000
	STAR_SS	8202.523	1	8202.523	1.022	0.314	0.009
Error	SAT	628606.319	118	5327.172			
	STAR_SS	947391.323	118	8028.740			
Total	SAT	39965500.000	122				
	STAR_SS	105265751.000	122				
Corrected Total	SAT	725695.902	121				
	STAR_SS	1106926.992	121				

a. R Squared = .134 (Adjusted R Squared = .112)

b. R Squared = .144 (Adjusted R Squared = .122)

There was not a statistically significant difference at the $p < .05$ level in SAT and STAR scores for gender: $F(2, 117) = 2.74$, $p = .069$. There was a statistically significant difference at the $p < .05$ level in SAT and STAR scores based on pathways: $F(2,117) = 9.35$, $p < .001$ (Table 38). The scores of students in Pathway 1 were significantly higher than those students who were in Pathway 2 for the SAT, $F(1, 118) = 17.718$, $p = .000$ and for STAR, $F(1, 118) = 15.711$, $p = .000$ (Table 41). An inspection of the mean scores (Tables 39 and 40) indicated that Pathway 1

students performed higher on the SAT test (M = 598.52, SD = 78.87) than Pathway 2 students (M = 542.21, SD = 66.98). The same was true of the STAR scores where Pathway 1 students performed higher (M = 960.17, SD = 93.09) than Pathway 2 students (M = 895.26, SD = 88.17). There was not a significant difference in student achievement by gender.

Summary of Chapter Four

The AP assessment data was a starting point and serves as a basis for future research. While there was a majority of students who earned a score of 1, therefore necessitating the categorical approach to analyses, the outcomes were still significant. The students who were in Pathway 1 ultimately scored better than the students who were in Pathway 2 when the AP assessments were compared. The data analysis for Research Question 2 was reported via descriptive statistics due to the lack of normality for skewness and kurtosis, meaning that the measurement scale for the data was categorical. The student SAT and STAR scores did pass normality and were therefore analyzed with statistical testing via a two-way MANOVA. There was no significant difference in the scores based on gender. There was a significant difference in scores based on middle school mathematics placement. This difference cannot necessarily be attributed solely to the course pathway described in this study. Further research is needed to determine if the difference was due to general student readiness or if the differences in courses students completed within their pathways was a key factor. The difference in significance does support the idea that students who were advanced in middle school were appropriately placed in their middle school courses as their scores remained consistent.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

The purpose of this causal comparative study was to investigate the differences in high school mathematics performance for males and females who were in different mathematics pathways, where Pathway 1 students completed algebra 1 in eighth grade and Pathway 2 students did not. Pathway 1 students completed a consolidated mathematics course combining seventh and eighth grade content in grade seven prior to completing algebra 1 in eighth grade. The study compared the courses students enrolled in from seventh grade to AP mathematics courses during either grade 11 or 12.

This chapter includes the following sections: (a) Overview of the Study and Discussion, (b) Research Questions and (c) the Study Limitations. Each Research Question addresses four components: (a) Results, (b) Limitations, (c) Related Research, (d) Implications for Educators, and (e) Implications for Future Research.

Overview of the Study and Discussion

The study allowed the researcher to analyze differences in student achievement (STAR, SAT, and AP mathematics tests) between mathematical pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female). The study took place in an urban district with an open enrollment policy for AP courses. This means that the students were allowed to enroll in an AP course if they wanted to, regardless of having a teacher recommendation, providing they had passed certain prerequisite courses. For AP Calculus, the students had to have passed pre-calculus and for AP Statistics, the students had to have passed algebra 2. The researcher utilized a sample of convenience that included 122 secondary school students in grade 11 or 12 enrolled in AP mathematics classes.

Research Questions

Research Question One

The following research question was addressed in this study:

1. Is there a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female)?

Non-Directional Hypothesis: There will be a significant difference in expected and observed results in AP mathematics scores (a score of 1, 2 or a score of 3-5) between the mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female).

This quantitative research question was used to determine if there was a difference in observed and expected AP scores (a score of 1, 2 or a score of 3-5), mathematics pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine), and gender identity (male, female). The data were all categorical for this question. Since the gender category needed to be collapsed, a 2 by 2 chi-square test for independence was used to analyze the data for significant differences in the number of students scoring below or above passing in AP courses based on pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). A chi-square test is appropriate to use when

analyzing this type of data because "a chi-square statistic is used to test the difference between the predicted and the observed relationships" (Meyers et al., 2006, p. 608).

Results. A chi-square test for independence indicated significant association between AP scores and middle school status, $\chi 2$ (1, n = 122) = 17.667, $p < .001$, *phi* = .381 (Pallent, 2016, p. 222).

Limitations. A limitation of this study is that due to its causal comparative nature, the population of the study lacks randomization (Fraenkel, Wallen, & Hyun, 2012). The groups were already established prior to the study commencing. It is impossible to know all factors that contributed to a student's decision to enroll in an AP mathematics course. Demographic information was also not included outside of gender and grade level therefore it is impossible to know if other factors outside of gender and middle school mathematics placement contributed to the AP placement selection and outcomes in this study.

Related Research. In a qualitative study, Showalter (2017) reported being "unable to discern whether students who progress in the algebra-calculus pipeline are more prepared for postsecondary mathematics *because* of their high school coursework or whether the difference is due to characteristics that led them to self-select into the upper-level mathematics courses" (p. 675).

Another area of research related to this study is understanding what happened to the students who were accelerated in middle school and did not enroll in AP mathematics. Many students show strong early potential but then lack the skills necessary to struggle through a problem. These students may have developed an "inadequate frustration tolerance" (Grobman, 2006, p.204) that interfered with their decision to follow the entire pathway to an AP mathematics course.

There exists comparison research regarding what typical eighth grade mathematics coursework consisted of and how it compares to typical eighth grade work post Common Core implementation. Eighth grade now consists of many more topics that were traditionally taught in algebra 1. While some studies showed positive outcomes for all students when everyone was accelerated in eighth grade (Allensworth, Nomi, Montgomery, & Lee 2009; Burris, Heubert, & Levin, 2004), these studies were conducted prior to Common Core implementation. Even then, "a careful comparison between high achievers in pre-acceleration and post-acceleration cohorts found that their mean scores on the Sequential I Regents Exam taken in eighth grade were statistically indistinguishable" (Burris et al., 2004, para. 23).

Implications for Educators. An ongoing debate in education is when to offer algebra 1. If future similar studies were to continue to show a significant difference in student scores in AP classes based on middle school placement, then advancing students in middle school, for those students who are ready for the challenging curriculum, is likely a necessity for their academic growth and high school enrollment in AP classes. This pathway could result in the implementation of accelerated middle school mathematics classes if they were to be deemed necessary. However, if educators choose the pathway of algebra 1 for all eighth grade, research by Burris et al., (2004) indicates success when students are provided with the needed supports. For educational leaders, a push to remove or implement middle school acceleration courses means potential restructuring at the high school level to accommodate students who want to double up in mathematics classes to reach the A.P. level or a restructuring of courses to include an accelerated or condensed path for students at the high school level. More training and professional development on differentiation techniques may also be required at a middle school level to accommodate a larger heterogeneously grouped population. This study revealed a

preponderance of scores in the 1-2 range on the AP mathematics exams. An implication of this is that additional support for students and training for teachers would be beneficial regardless of the pathways that are implemented. Any of these potential changes might also need to come with presentations for parents to provide information regarding Common Core State Standards, mathematical course progressions, and adjustments in pathways for their enrolled students.

Potential Future Research. This study focused primarily on students who were enrolled in AP Mathematics courses grade 11 or 12. It did not take into consideration what happened to the students who had been in an accelerated mathematics class in seventh grade and ultimately did not end up taking at least one AP mathematics class. A follow up qualitative study could address the reasons why those students, who were deemed ready for advanced mathematics in middle school, did not take advantage of the opportunity to take AP classes. Another follow up question might include whether the students who did not pursue AP classes are college bound or not. Including the concept of mindset to elevate this research would be another area of interest to all students but specifically marginalized students who may not see enough people of resemblance in mathematics fields (Ford & Whiting, 2010). Additionally, including and focusing on other demographics such as race, ethnicity, and socioeconomic status could accentuate this research (Richardson, et al, 2016, Ford & Whiting, 2010). Other demographics, such as free and reduced lunch and highest parental education status were not included in this study, however based on the breakdown of the population in the city where the research was conducted, these attributes could have also been valuable information.

Research Question Two

The following research question was also addressed in this study:

2. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender identity (male, female)?

a. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine)?
b. Is there a significant difference in student achievement (STAR Assessment and SAT Mathematics test) between males and females?
c. Is there a significant interaction for student achievement (STAR Assessment and SAT Mathematics test) between mathematics path (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine) and gender (male, female)?

Non-Directional Hypothesis: There will be a significant difference in student achievement between pathway and gender.

Assessment scores were obtained for two standardized assessments and compared based on course enrollment in middle school and gender. The student achievement data (STAR Assessment, SAT Mathematics test) is interval in nature and the mathematical pathways and gender are categorical. A 2x2 MANOVA was used to analyze both gender and pathways as a MANOVA is appropriate to use when "assessing the effects of one dichotomous (two-group)

independent variable on two or more quantitative dependent variables" (Meyers et al., 2006, p. 365).

Results. A two-way MANOVA was conducted to investigate the impact of gender and middle school placement on the SAT and STAR assessments. The independent variables were gender (male, female) and pathway (Pathway 1: students who were in an accelerated mathematics course beginning in seventh grade and completed algebra 1 in grade eight, Pathway 2: students who completed algebra 1 in grade nine). Two dependent variables were used: SAT and STAR. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, and homogeneity of variance matrices, with no serious violations noted. After recording a significant Wilks' Lambda, mean comparisons were conducted between each level of the two dependent variables. There was not a statistically significant difference at the $p < .05$ level in SAT and STAR scores for gender: $F(2, 117) = 2.74$, $p = .069$. There was a statistically significant difference at the $p < .05$ level in SAT scores for middle school status: $F(2,117) = 9.35$, $p < .001$. The scores of students who were in Pathway 1 were significantly higher than those students who were in Pathway 2. An inspection of the mean scores indicated Pathway 1 students performed statistically significantly higher on the SAT test ($M = 598.52$, $SD = 78.87$) than Pathway 2 students ($M = 542.21$, $SD = 66.98$). The same was true of the STAR scores. Pathway 1 students performed significantly higher ($M = 960.17$, $SD = 93.09$) than Pathway 2 students ($M = 895.26$, $SD = 88.17$). There was not a significant interaction in student achievement by gender.

Limitations. This study was based on only one urban school district, therefore, sample size was a limitation. There were only 122 participants in the final data analysis. A larger

population may have resulted in a wider spread of test scores. Another limitation to only being in one urban district is that the results cannot be generalized to other districts.

Self-reported data in the demographic questionnaire is a limitation because it relies on participants to provide accurate data about themselves. There may be biases in the data such as selective memory or exaggeration. Students were asked how many absences they had but were not given the opportunity to look up an exact number. They just responded based on memory. There is potential for some selective memory in the attendance responses. Students were similarly asked to report how often they completed their homework. Some could have exaggerated this response either in a positive or negative way.

Another limitation was the lack of prior research post common core state standards (CCSS) implementation. The researcher found an abundance of literature from prior to 2010, but not much post CCSS adoption.

Related Research. Howell (2019) conducted a study regarding AP scores of students who had enrolled in an AP class under traditional criteria (B average or better) compared to those that had enrolled in an AP course having not met traditional requirements (B- average or less). In the study, $n = 486$ students enrolled in AP Calculus. There was a statistically significant difference between the AP scores, with traditional students having a mean score of 3.94 (SD = 1.09) as compared to nontraditional students who had a mean score of 3.23 (SD = 1.09) and p <.001. However, although the means were significantly different, through a multiple regression analysis, it was found that the type of student (traditional verses non-traditional) was not a predictor of AP achievement when analyzed along with GPA, PSAT/NMSQT, student SES, and prior AP experience. Only PSAT scores and GPA were found to be significant predictors of AP Achievement.

Implications for Educators. Since this was a causal comparative study, there can be no causal implications. Students who were identified for acceleration in seventh grade tended to score higher on AP, SAT, and STAR assessments, but it is unclear if the accelerated pathway was the cause of those results. If there are students that have the mathematics capability, then acceleration is available to support them in growing their strengths and talents. If students were not chosen for the accelerated path in middle school, or chose not to follow that path, there was still an opportunity to double up on mathematics classes later in their high school career to reach AP classes by grade 12. This allowed students to enter a pathway to AP classes when they may have been more developmentally ready. In this study there were more students that were enrolled in AP classes from Pathway 2 than Pathway 1. Educators need to determine the benefits of multiple pathways and how to best service the needs of all students regardless of ability so that they have the most opportunities to succeed.

Potential Future Research. One way to expand upon this research would be to include a variety of urban, suburban, and rural schools for comparison. Increasing this study to a longevity study to review how many students attended two- or four-year colleges post high school and whether their AP credits were accepted at their post-secondary schools would be an avenue of research to explore. Determining and reviewing success criteria for these students' post-secondary school has potential for impacting AP enrollment especially if those students who were accelerated in middle school and not enrolled in AP classes were included in the study as well. Another area for future research is to try and determine why so many students in both pathways received a score of one on the AP exam.

Another area of potential future research is to include socio-economic status. Domina (2014) used Early Childhood Longitudinal Study's Kindergarten Cohort (ECLS–K) data and

found that students in core mathematics classes are raised in families with a lower income and educational level. Students enrolled in geometry in eighth grade scored almost a full standard deviation apart in the achievement gap from their peers enrolled in a general eighth grade mathematics class. The study showed that the overall indication was that access to advanced courses was greatly based on student achievement, but it was not as clear as to whether the actual placement in the courses improved achievement. Some of the data even indicated that students in advanced courses have less growth in achievement than their general education classmates (Domina, 2014). The study indicated that "enrolling students in advanced middle school mathematics courses has positive average effects on achievement" and "supports the push to intensify mathematics curricula in American middle and high schools" (p. 1962), but it also cautions that "expanding advanced course enrollments may reach a point of diminishing returns if students are placed into courses for which they are unprepared" (p. 1962). More research is needed to strengthen these claims in one direction or another.

Study Limitations

Internal Validity

Participant characteristics were a minimal internal threat to this study. This was particularly relevant since it was unknown if there were differences in personal characteristics of AP students in Pathway 1 and Pathway 2. To address this, there was a demographic survey given to students in all AP mathematics courses which included a checklist of mathematics courses completed and student perceptions of mathematics. The qualitative data were collected from individuals in both groups to examine the phenomenon more closely (Creswell & Plano Clark, 2011). There were 54 students in Pathway 1 and 68 in Pathway 2. Gender was the only other subject characteristic considered. While the number of males to females in the study was

not exactly even, they were relatively close with 56 male participants and 66 female participants included in the final calculations. Ethnicity and socioeconomic status were not considered as part of the demographics for this study.

Selection-maturation could have been a threat if there were a larger proportion of grade 11 participants than grade 12 students in any of the AP courses. There were 36 students in grade 11 and 86 students in grade 12 in the final cleaned data.

Researcher bias is another internal threat but will be minimal as the researcher has completed an extensive review of the literature and found accounts where acceleration has yielded positive results and accounts where it has not. The data were also provided to the researcher with no extraneous information that would bias the results of the research.

Instrumentation is a very minimal threat to the quantitative portion of this study as all the testing instruments were normed, valid, and reliable assessments and administered under strict testing conditions.

To combat mortality in this study, the researcher visited the AP classes in person to ask students to participate. The researcher answered any questions the students had and attempted to reassure them that their information would remain confidential.

Location for this study should not influence the results because all participants were from the same school. "A location threat is possible if the data are collected under different conditions for different groups" (Fraenkel, Wallen, & Hyun, 2012, p.371). As stated, the researcher visited each AP class, explained the study, and was available for questioning.

"Implementation, history, maturation, attitudinal, and regression threats do not affect this kind of causal-comparative study" (Fraenkel et al., 2012, p.373).

External Validity

Generalizability is a threat to external validity. This is due to the fact that the population is a sample of convenience. To combat this threat a detailed description of the population is provided so that other parties interested in referencing the results of the study are able to determine how similar their own population is to the one in this study.

Mortality is a threat to validity because "the sample actually studied is often not the sample initially selected" (Fraenkel et al., 2012, p. 344). There were 181 students enrolled in AP classes and the researcher was able to obtain consent to participate from 73% of the students (n = 131). After data cleaning, the population studied was still large enough to conduct statistical analyses, with 122 participants.

Conclusion

In causal comparative research, the main goal is to "identify and define the particular phenomena of interest and then to consider possible causes for, or consequences of, these phenomena" (Fraenkel, Wallen, & Hyun, 2012, p. 369). The purpose of this study was to explore the placement and success phenomena for the students who were not enrolled in advanced mathematics in middle school but ended up enrolling in an AP class regardless and how their overall success compared to those that were enrolled in an advanced class in middle school. While the study indicated that there were not differences in gender identity, students who were in Pathway 1, had higher AP, SAT, and STAR mathematics scores by the time they reached grades 11 or 12. Despite the higher scores from Pathways 1 students, the results indicated that it was critical to improve the scores of students from both pathways. "The most powerful method for demonstrating the causal nature of causal-comparative findings is to do subsequent experiments in which the presumed cause or causes of the outcomes being studied is

manipulated." (Gall, Gall, & Borg, 2003, p. 316). Further research in this field would be beneficial. Expanding to other school districts and including other demographics would accentuate the findings of this study.

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Appendix A: IRB Approval Letter

JE **Jessica Eckstein** June 20, 2019 at 11:21 AM

IRB Approval Email

To: Rachel J. Saunders, Kristy Zaleta, Marcia Delcourt, Cc: WCSU IRB Details

Hello Ms. Saunders,

I am pleased to inform you that your I.R.B. protocol number 1819-174 has been approved by Full review. This email is documentation of your official approval to start your research. If you need a copy of this official approval for funding purposes, please let me know oconnorc@wcsu.edu. The WCSU I.R.B. wishes you the best with your research.

You have 1 year from the date of this email to complete your research; if you are still conducting that date, you will need to fill out a renewal application. When are you finished with your study please fill out and return via email a Termination/Completion Report (available here: http://wcsu.edu/irb/forms.asp) so we know your study is complete.

Finally – and most importantly! – we have recently learned that current BOR technology policies do *not* guarantee privacy of *any* info stored on work computers physically, remotely, or otherwise (i.e., laptop, dropbox, etc.). As such, to maintain the truth of any anonymity or confidentiality promises you make to participants (consent form, for example), you will need to store all electronic data obtained from those human subjects on a system/computer/file *not* connected to any CSU system. It is your responsibility as the primary researcher to make sure personal data of participants remains securely private – something not guaranteed in the currently existing CSU system. *Rest assured,(because it's ridiculous to expect faculty to store work-related research on non-work-related systems and/or to conduct research where participants are not guaranteed anonymity/confidentiality), we are working to gain an exception for research purposes to this policy. But until then, it's technically and legally possible for anyone in the system office to access your participants' data at any time – without your consent or knowledge before doing so… which makes any guarantees made on research documents (e.g., consent forms) deceptive unless info is stored elsewhere.*

Thanks,

Jessica Eckstein, Ph.D.
Chair, Institutional Review Board
Western Connecticut State University
www.wcsu.edu/irb

Appendix B

May 2019

Dear (Superintendent),

My name is Rachel Saunders. I am a doctoral candidate for the EdD in Instructional Leadership program at Western Connecticut State University and am in the process of working on my dissertation. I have chosen to investigate the different pathways that lead students to eventually participate in AP Math courses. I have designed a Mixed Methods study to collect data on the pathways, success rates, and student perceptions of their career in mathematics. I believe that the results of this investigation will help instructional leaders at the middle school level make informed decisions about accelerated mathematics placement. My proposal involves an analysis of standardized test scores, including SAT, PSAT 10, AP exam, and STAR scores for all juniors and seniors in AP mathematics courses as well as the math courses they were enrolled in from seventh to eleventh or twelfth grade. It will also include a demographic survey from which participants will be selected and invited to participate in an interview to gain insight into what motivated them to enroll in AP mathematics courses.

As part of the study, I will be collecting four types of student information. I plan to administer a demographic survey for general background information and use an interview protocol with select students in order to gather information from a proportional sample of the population. The survey should take no more than 10 minutes and will be administered during non-instructional flex time after the completion of all AP exams. The audio-recorded interviews will take approximately 30 minutes per student and can also be completed during non-instructional flex time, or before or after school, in June, at the convenience of the participants. I will request students' STAR Mathematics scores, AP Math scores, PSAT 10 Math scores, and SAT Math scores along with math course enrollment from grades 7 through 12 prior to the end of the school year from a district administrator.

I will ask the AP teachers for consent for me to attend their flex time and explain my research to the students. I will ask them to distribute and collect the opt out forms and demographic surveys after two weeks, following the description of the study. The commitment from AP teachers includes permission to attend their classes and explain the research to the students (5-10 minutes), collecting parent/guardian opt-out forms, distributing and collecting the demographic surveys following the description of the study with the assistance of the researcher, as well as assistance in selecting interviewees and creating and interview schedule during non-instructional flex time following review of the demographic survey.

Participation in this study is completely voluntary and participants may withdraw at any time. The students will have two weeks to hand in the parent opt out form if they do not want their student to be included in the study. Students will also be asked for their assent to participate. Participation in this study will not affect a student's grade. Privacy will be protected for all participants (district, school, teacher, student) by numerical coding. All identities will be maintained in a secure location to protect confidentiality. All audio recordings will be deleted after transcripts are developed. Quantitative results will only be reported in aggregate form. Pseudonyms will be used when any qualitative data are reported. Data, without any personal identifying information, will be reviewed by the faculty supervisors, Dr. Zaleta and Dr. Delcourt, in order to obtain feedback and support during analyses. Regarding the qualitative

data, an outside reviewer, Dr. Reine Issa, will also be provided with conclusions, findings, implications, themes, categories, codes and data related to the findings and the line of argument for those findings in order to follow and examine the line of reasoning created by the investigator. Any data presented for review will not have identifying information.

The research project has been reviewed and approved by the WCSU Institutional Review Board. If you have questions concerning the right of subjects involved in this research study, please email the WCSU Assurances Administration at irb@wcsu.edu and mention Protocol Number (1819-174). This study is valid until 6/20/2020. If you have any questions, please feel free to contact me or any of my advisors.

Sincerely,
Rachel Saunders
Western Connecticut State University Doctoral Student
rjgsaunders@gmail.com

Dr. Kristy Zaleta
Principal, Rogers Park Middle School
zaletk@danbury.k12.ct.us

Dr. Marcia A. B. Delcourt
Coordinator, EdD in Instructional Leadership Program
Western Connecticut State University
delcourtm@wcsu.edu

I agree to allow this research to be conducted in (district name):

_____	_____	_____
Superintendent Name (Print)	Superintendent Signature	Date

Appendix C

May 2019

Dear (Principal),

My name is Rachel Saunders. I am a doctoral candidate for the EdD in Instructional Leadership program at Western Connecticut State University and am in the process of working on my dissertation. I have chosen to investigate the different pathways that lead students to eventually participate in AP Math courses. I have designed a Mixed Methods study to collect data on the pathways, success rates, and student perceptions of their career in mathematics. I believe that the results of this investigation will help instructional leaders at the middle school level make informed decisions about accelerated mathematics placement. My proposal involves an analysis of standardized test scores, including SAT, PSAT 10, AP exam, and STAR scores for all juniors and seniors in AP mathematics courses as well as the math courses they were enrolled in from seventh to eleventh or twelfth grade. It will also include a demographic survey from which participants will be selected and invited to participate in an interview to gain insight into what motivated them to enroll in AP mathematics courses.

As part of the study, I will be collecting four types of student information. I plan to administer a demographic survey for general background information and use an interview protocol with select students in order to gather information from a proportional sample of the population. The survey should take no more than 10 minutes and will be administered during non-instructional flex time after the completion of all AP exams. The audio-recorded interviews will take approximately 30 minutes per student and can also be completed during non-instructional flex time, or before or after school, in June, at the convenience of the participants. I will request students' STAR Mathematics scores, AP Math scores, PSAT 10 Math scores, and SAT Math scores along with math course enrollment from grades 7 through 12 prior to the end of the school year from a district administrator.

I will ask the AP teachers for consent for me to attend their flex time and explain my research to the students. I will ask them to distribute and collect the opt out forms and demographic surveys after two weeks, following the description of the study. The commitment from AP teachers includes permission to attend their classes and explain the research to the students (5-10 minutes), collecting parent/guardian opt-out forms, distributing and collecting the demographic surveys following the description of the study with the assistance of the researcher, as well as assistance in selecting interviewees and creating and interview schedule during non-instructional flex time following review of the demographic survey.

Participation in this study is completely voluntary and participants may withdraw at any time. The students will have two weeks to hand in the parent opt out form if they do not want their student to be included in the study. Students will also be asked for their assent to participate. Participation in this study will not affect a student's grade. Privacy will be protected for all participants (district, school, teacher, student) by numerical coding. All identities will be maintained in a secure location to protect confidentiality. All audio recordings will be deleted after transcripts are developed. Quantitative results will only be reported in aggregate form. Pseudonyms will be used when any qualitative data are reported. Data, without any personal identifying information, will be reviewed by the faculty supervisors, Dr. Zaleta and Dr. Delcourt, in order to obtain feedback and support during analyses. Regarding the qualitative

data, an outside reviewer, Dr. Reine Issa, will also be provided with conclusions, findings, implications, themes, categories, codes and data related to the findings and the line of argument for those findings in order to follow and examine the line of reasoning created by the investigator. Any data presented for review will not have identifying information.

The research project has been reviewed and approved by the WCSU Institutional Review Board. If you have questions concerning the right of subjects involved in this research study, please email the WCSU Assurances Administration at irb@wcsu.edu and mention Protocol Number (1819-174). This study is valid until 6/20/2020. If you have any questions, please feel free to contact me or any of my advisors.

Sincerely,
Rachel Saunders
Western Connecticut State University Doctoral Student
rjgsaunders@gmail.com

Dr. Kristy Zaleta
Principal, Rogers Park Middle School
zaletk@danbury.k12.ct.us

Dr. Marcia A. B. Delcourt
Coordinator, EdD in Instructional Leadership Program
Western Connecticut State University
delcourtm@wcsu.edu

I agree to allow this research to be conducted in (school name):

_____	_____	_____
Principal Name (Print)	Principal Signature	Date

Appendix D

May 2019

Dear (Participating Teacher),

My name is Rachel Saunders. I am a doctoral candidate for the EdD in Instructional Leadership program at Western Connecticut State University and am in the process of working on my dissertation. I have chosen to investigate the different pathways that lead students to eventually participate in AP Math courses. I have designed a Mixed Methods study to collect data on the pathways, success rates, and student perceptions of their career in mathematics. I believe that the results of this investigation will help instructional leaders at the middle school level make informed decisions about accelerated mathematics placement. My proposal involves an analysis of standardized test scores, including SAT, PSAT 10, AP exam, and STAR scores for all juniors and seniors in AP mathematics courses as well as the math courses they were enrolled in from seventh to eleventh or twelfth grade. It will also include a demographic survey from which participants will be selected and invited to participate in an interview to gain insight into what motivated them to enroll in AP mathematics courses.

As part of the study, I will be collecting four types of student information. I plan to administer a demographic survey for general background information and use an interview protocol with select students in order to gather information from a proportional sample of the population. The survey should take no more than 10 minutes and will be administered during non-instructional flex time after the completion of all AP exams. The audio-recorded interviews will take approximately 30 minutes per student and can also be completed during non-instructional flex time, or before or after school, in June, at the convenience of the participants. I will request students' STAR Mathematics scores, AP Math scores, PSAT 10 Math scores, and SAT Math scores along with math course enrollment from grades 7 through 12 prior to the end of the school year from a district administrator.

I will ask the AP teachers for consent for me to attend their flex time and explain my research to the students. I will ask them to distribute and collect the opt out forms and demographic surveys after two weeks, following the description of the study. The commitment from AP teachers includes permission to attend their classes and explain the research to the students (5-10 minutes), collecting parent/guardian opt-out forms, distributing and collecting the demographic surveys following the description of the study with the assistance of the researcher, as well as assistance in selecting interviewees and creating and interview schedule during non-instructional flex time following review of the demographic survey.

Participation in this study is completely voluntary and participants may withdraw at any time. The students will have two weeks to hand in the parent opt out form if they do not want their student to be included in the study. Students will also be asked for their assent to participate. Participation in this study will not affect a student's grade. Privacy will be protected for all participants (district, school, teacher, student) by numerical coding. All identities will be maintained in a secure location to protect confidentiality. All audio recordings will be deleted after transcripts are developed. Quantitative results will only be reported in aggregate form. Pseudonyms will be used when any qualitative data are reported. Data, without any personal identifying information, will be reviewed by the faculty supervisors, Dr. Zaleta and Dr. Delcourt, in order to obtain feedback and support during analyses. Regarding the qualitative

data, an outside reviewer, Dr. Reine Issa, will also be provided with conclusions, findings, implications, themes, categories, codes and data related to the findings and the line of argument for those findings in order to follow and examine the line of reasoning created by the investigator. Any data presented for review will not have identifying information.

The research project has been reviewed and approved by the WCSU Institutional Review Board. If you have questions concerning the right of subjects involved in this research study, please email the WCSU Assurances Administration at irb@wcsu.edu and mention Protocol Number (1819-174). This study is valid until 6/20/2020. If you have any questions, please feel free to contact me or any of my advisors.

Sincerely,
Rachel Saunders
Western Connecticut State University Doctoral Student
rjgsaunders@gmail.com

Dr. Kristy Zaleta
Principal, Rogers Park Middle School
zaletk@danbury.k12.ct.us

Dr. Marcia A. B. Delcourt
Coordinator, EdD in Instructional Leadership Program
Western Connecticut State University
Delcourtm@wcsu.edu

I agree to allow this research to be conducted in my classroom:

_____	_____	_____
Teacher Name (Print)	Teacher Signature	Date

Appendix E

May 2019

Dear Parents or Guardians,

My name is Rachel Saunders and I am a doctoral candidate in the Educational Instructional Leadership Program at Western Connecticut State University. I am implementing a dissertation project. The purpose of this study is to analyze what leads students to enroll in AP Mathematics courses as well as determine any differences in achievement results based on the students' math course enrollment from seventh through twelfth grade. The results of the study will have potential benefits to middle school math leaders in making placement decisions for upcoming mathematics students.

I would like your child to participate in this study. During this project, I would like to collect (1) your student's STAR Mathematics scores, (2) their AP Math scores, (3) their PSAT 10 scores and (4) their SAT scores. As part of the study, I will ask your student to: (1) answer a brief survey (10 minutes) regarding his or her experience in math courses up to and including their AP course, (2) potentially participate in an audio-recorded interview (30 minutes) about their experiences in mathematics up until this point. All students in the project will participate in the regular mathematics curriculum and will not miss any of their mathematics classes. Some students will be invited to participate in quick follow up interviews that may take place during school hours as part of their flex time, or before or after school at their convenience.

Participation in this study is completely voluntary. You are free to withdraw your child from the study at any time, students who agree to participate will submit all survey information to me, the researcher, through a pen and paper survey. Privacy will be protected, as students' names will be a unique number. All student identities will be maintained in a secure location to protect confidentiality. Privacy will be protected for all participants (district, school, teacher, student) by numerical coding. All identities will be maintained in a secure location to protect confidentiality. All audio recordings will be deleted after transcripts are developed. Quantitative results will only be reported in aggregate form. Pseudonyms will be used when any qualitative data are reported. Data, without any personal identifying information, will be reviewed by the faculty supervisors, Dr. Zaleta and Dr. Delcourt, in order to obtain feedback and support during analyses. Regarding the qualitative data, an outside reviewer, Dr. Reine Issa, will also be provided with conclusions, findings, implications, themes, categories, codes and data related to the findings and the line of argument for those findings in order to follow and examine the line of reasoning created by the investigator. Any data presented for review will not have identifying information. Participation or non-participation will not affect a student's grade.

The research project has been reviewed and approved by the WCSU Institutional Review Board. If you have questions concerning the right of the subject involved in research studies please email the WCSU Assurances Administration at irb@wcsu.edu and mention Protocol Number (1819-174). This study is valid unit 6/20/2020. If you have any questions or concerns, please feel free to contact me.

Sincerely,
Rachel Saunders
Danbury Middle Schools

Western Connecticut State University Doctoral Student
saundr@danbury.k12.ct.us

Dr. Kristy Zaleta
Principal, Rogers Park Middle School
zaletk@danbury.k12.ct.us

Dr. Marcia A. B. Delcourt
Coordinator, EdD in Instructional Leadership Program
Western Connecticut State University
Delcourtm@wcsu.edu

DENIAL OF PERMISSION

Please complete this form and return to your child's teacher ONLY if you do NOT wish your child to be a part of this study.

Student Name _____

I **DO NOT** give permission for my child, named above, to participate in this study.

_____
Parent/Guardian Name

_____
Parent/Guardian Signature

Date _____

Appendix F

February 2019

Dear Student,

I am a doctoral candidate in the Educational Instructional Leadership Program at Western Connecticut State University. I am doing a research study and I would like you to be a part of it. I will send an opt-out consent form home with you for your parents or guardians to look over.

In this study, I will be examining student experiences that lead to enrollment in AP mathematics courses and the overall achievement on certain standardized assessments of students in the AP courses. The results of the study will have potential benefits to middle school math leaders in making placement decisions for upcoming math students.

As a part of the study, I will be asking each of you to complete a short demographic survey. After a review of the results of the survey, I will select a minimum of 30 students representing a range of responses and invite these students to participate in an approximately 30-minute interview about experiences in mathematics courses at the secondary level.

Your participation in the study is completely voluntary. If you do decide to participate, I will not use your name in the study. I will use pseudonyms for all names. You will not be graded on this for your math class. All the information will be kept private.

Data, without any personal identifying information, will be reviewed by the faculty supervisors, Dr. Zaleta and Dr. Delcourt, in order to obtain feedback and support during analyses. Regarding the qualitative data, an outside reviewer, Dr. Reine Issa, will also be provided with conclusions, findings, implications, themes, categories, codes and data related to the findings and the line of argument for those findings in order to follow and examine the line of reasoning created by the investigator. Any data presented for review will not have identifying information.

If you have any questions, please ask me. If you would like to be in the study, please print and sign your name below.

Thank you,
Mrs. Saunders
Danbury Middle Schools
Western Connecticut State University Doctoral Student
saundr@danbury.k12.ct.us

Dr. Kristy Zaleta
Principal, Rogers Park Middle School
zaletk@danbury.k12.ct.us

Dr. Marcia A. B. Delcourt
Coordinator, EdD in Instructional Leadership Program
Western Connecticut State University
Delcourtm@wcsu.edu

_____ _____ _____

Student Name (Print)	Student Signature	Date

Appendix G

Rachel Saunders <saundr@danbury.k12.ct.us> Thu, Nov 19, 2020, 12:19 PM

to Kate

Hi Kate,

I wanted to follow up with this as I was wondering if the final document was released? I am currently working on my dissertation and it involves assessing overall outcomes of middle school acceleration as measured by AP scores, SAT scores and STAR scores of Juniors and Seniors in AP courses comparing whether or not they were in an accelerated program in middle school. Part of my research documents the shift in mathematics standards in 2010 and how many programs did not adjust their acceleration policies in light of this. I remember there was an awesome graphic in this draft that provided a clear view of how algebra based topics were shifted into the middle grades with the switch to CCSS and I would love to gain permission to use and cite in my dissertation. Any help you may be able to provide would be greatly appreciated. I truly value the work of IM and find my views of how mathematics should be taught are highly aligned to the views of IM.

Thank you so much for your time,

Rachel Saunders

Kate Nowak <kate@illustrativemathematics.org> Nov 19, 2020, 2:52 PM

to me

Hello! Yes, you can retrieve it from here: https://www.illustrativemathematics.org/wp-content/uploads/2020/06/2020-05-07-FINAL-Guidance-for-accelerating-students-in-mathematics.pdf

It's got a copyright stamp on it, but you can use this email as permission from IM to use the graphic, along with any other excerpts you would like to cite, in your dissertation.

--

Kate Nowak
Vice President, Product Strategy

Rachel Saunders <saundr@danbury.k12.ct.us> Nov 19, 2020, 2:58 PM

to Kate

Thank you SO much! I really appreciate this!!

Rachel

Appendix H

Student Demographic Survey

1. What is your name? _____
2. Do you identify as: male female Choose not to identify
3. What is your current grade? 10 11 12
4. Were you in an accelerated math class in 7th grade?
    a. Yes
    b. No
5. What AP course(s) are you currently taking? (circle ALL that apply)
    a. AP Statistics
    b. AP Calculus AB
    c. AP Calculus BC
6. What previous courses have you completed? (Choose ALL that apply)
    a. Algebra 1
    b. Algebra 2
    c. Geometry
    d. Pre-Calculus
7. When did you start attending school in this district?
    a. Elementary School
    b. Grade 6
    c. Grade 7
    d. Grade 8
    e. Grade 9
    f. Grade 10
    g. Grade 11
    h. Grade 12
8. How many absences have you had this year?
    a. More than 10
    b. 5 – 9
    c. 1 – 4
    d. I have not been absent
9. How would you best describe your feelings about mathematics?
    a. I don't like math
    b. Math is okay – I'm indifferent
    c. I like Math
    d. I love Math
10. Do you always do your homework?
    a. Yes, all of the time
    b. Most of the time
    c. Occasionally
    d. Never

EdD in Instructional Leadership
Department of Education and Educational Psychology
Dissertation Registration Form

Student: Rachel J. G. Saunders Date: 07/22/2025

Dissertation Title:

PATHWAYS TO AP MATHEMATICS IN AN URBAN SCHOOL DISTRICT

Dissertation Committee Members: See attached Dissertation Approval Page

For Office Use Only.

Marcia A. B. Delcourt, PhD	*Marcia A. B. Delcourt*	07/23/2025
Dissertation Committee Chair	Signature	Date
Marcia A. B. Delcourt, PhD	*Marcia A. B. Delcourt*	07/23/2025
Program Coordinator	Signature	Date
Joan Palladino, EdD	Joan S. Palladino	7/23/202
Dean, School of Professional Studies	Signature	Date