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Academic and Demographic Patterns of Students Placed in Early Algebra I Acceleration

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ABSTRACT

In the United States, there had been a push for Algebra for All in the early 1990's in an effort to increase performance on international assessments and provide equity for low-income students and students of color. As the number of students in eighth grade Algebra I increased, a small number of students enrolled in seventh grade Algebra I also increased. The purpose of this quantitative study is to identify and evaluate demographic and academic patterns of students placed in this early acceleration at the middle school level looking at the continuation of acceleration, higher achievement, and an increase in the number of students successfully completing calculus by their senior year within a suburban Midwest public school district.

Approximately 4712 students were included in the study. There were 237 students who were enrolled in seventh grade Algebra I, 1634 enrolled in eighth grade Algebra I, and 2841 enrolled in ninth grade Algebra I. During this time the enrollment in seventh grade Algebra I went from 4 students to 123 students. The expected course pathway completion, ACT mathematics score, and EOC levels were examined over a six-year period. Patterns in demographics such as gender, racial groups, socio-economic groups, along with programs and services such as special education and gifted programs were identified and reported. It was found that minority and low socio-economic groups were underreported in the accelerated Algebra I courses, however were able to show higher than average performance, and lower than average expected course pathway completion. Additionally, as the enrollment increased in the seventh grade Algebra I, performance decreased in all groups.

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DEDICATION

This dissertation is dedicated to my father, Bill Klahn. He was my inspiration for finishing my doctoral degree. He always believed in the importance of education and we shared a love of mathematics. He and my mom gave me a life that allowed me to pursue my dream of becoming a math teacher. The years leading up to finishing this degree were filled with a lot of ups and downs but one thing was always constant during those years and beyond… his love and pride for me. While he was not able to be here to see the end, with the completion of this dissertation and dedicating it to him, I am extremely proud to be his daughter.

CHAPTER 1

INTRODUCTION

Educational acceleration has been a part of education in the United States since the early years of the country. As early as the 1600s, students were taught one-on-one by tutors and in the 1700s, students began attending school in one-room school houses. This allowed for individualized instruction. Students worked at a pace that fit their ability allowing for students with higher ability to accelerate through their studies at a faster rate than their same-age peers. The current United States education system is organized, in most cases, by grades based on ages of students as opposed to ability, motivation and mindsets. Current methods of educational acceleration and thoughts regarding acceleration vary throughout the country (Colangelo et al., 2004). Educational acceleration is defined by Pressey (1949) as, "occurring when students move through traditional curriculum at rates faster than typical" (p. 2). Educational theories emphasize the importance of adequate preparation for each level of education as well as possible benefits of acceleration for qualified students (Piaget, 1967; Pressey, 1949; Vgotsky, 1986).

Mathematics, and particularly the mathematics instruction methods in the United States (U.S.) have evolved throughout the ages. During this time, acceleration of students through mathematics education has been a topic of discussion. Math acceleration typically occurs most in the middle school years (Daugherty et al., 2017). When a student enters middle school, they may have shown to be gifted or talented in the area of mathematics and placed on accelerated tracks. Acceleration in math at the middle school level typically means completing the first course of algebra, the gatekeeper course, during eighth grade (Daugherty et al., 2017). However, some students have actually completed the first course of algebra during seventh grade.

The district of interest in this study utilized the practice of early acceleration of students into Algebra I in seventh grade. The district began enrolling seventh graders into Algebra I in 2008 when three seventh grade students (0.33% of seventh grade enrollment) were placed in Algebra I. By 2014, there were 140 seventh grade students (12.77% of seventh grade enrollment) in Algebra I. This is an increase of 4567% since 2008. The enrollment of Algebra I students in middle school, both grades 7 and 8, during the same time increased by 134% and the total district enrollment for Algebra I at the high school level increased by 24%.

Seventh grade students enrolled in Algebra I were originally placed in eighth grade Algebra I classes. Once the numbers increased to allow for full seventh grade Algebra I classes, they were created. Selection for enrollment in seventh grade Algebra I in the district included the use of the state performance test, an algebra prognosis test, and a teacher recommendation.

With the extreme growth in the number of seventh grade students enrolled in Algebra I within this school district, the current study seeks to examine the academic and demographic patterns of students who are placed into early acceleration of Algebra I in seventh grade. These patterns will also be compared to groups of students within the same district who were enrolled in Algebra I in eighth and ninth grades. Various studies discuss the effects of students enrolled in Algebra I in eighth grade. Some studies point to positive results for students who are accelerated and others show students who may be accelerated too soon struggle in subsequent years (Penner et al., 2015; Liang et al., 2012;

Loveless, 2008; Mccoy, 2005; Smith, 1996; Spielhagen, 2006). A report by Pirtle (2019) discusses the disparity of minority students enrolled in acceleration programs. The percentage of black students enrolled in gifted and talented education (GATE) programs are consistently lower than the percentage of black students in the total enrollment. Additionally, the percentage of black students in remedial programs far outnumber the percentage of enrollment.

Background

Recently, the acceleration of middle school mathematics students has drawn added attention due to concerns of how the U.S. historically performs on international assessments relative to students from similar socioeconomic populations. The 2019 Programme for International Student Assessment (PISA) reported the U.S. performed below average in mathematics and is ranked 37th out of 78 participating countries (OECD, 2016, 2019). The report's findings suggest U.S. students demonstrate weaknesses in tasks requiring higher cognitive demand. Further, only 50% of U.S. students stated they are interested in learning mathematics which was below the average of the countries in the Organization for Economic Co-operation and Development (OECD). Over one-quarter (26 percent) of 15-year-olds in the U.S. do not reach the PISA baseline of mathematics proficiency. This baseline level is the threshold that includes skills that enable students to be quantitatively productive in their lives. Also, only 2% of students in the U.S. reach the highest level of performance (OECD, 2016, 2019).

Since 1995, the Trends in International Mathematics and Science Study (TIMSS) has reported mathematics achievement every four years of students across countries that include the U.S. While the U.S. has shown steady improvement in mathematics since

1995, eleven countries still outperform U.S. students. In the recent report, U.S. eighth grade students scored an average of 518 which was above the overall average for all countries of 500. However, this score is only marginally (3.6%) above the average, whereas the top five performing countries scored 20.2% above the population average (National Center for Education Statistics, 2015).

In the U.S., a response to the results of these international tests and studies has been a greater push for eighth grade algebra. In 1982, educator and civil rights advocate Robert Moses, and in 1990, the Clinton Administration advocated strongly for students to study algebra before they reach high school. They cited a need to provide equity for low-income students and students of color and for becoming more competitive at the international level. Several states, including California in 2008 and Minnesota in 2011, followed suit by requiring all eighth grade students to be enrolled in Algebra I (Loveless, 2008). From 1990 to 2011, the percentage of eighth grade students taking advanced mathematics (Algebra I, Geometry, or Algebra II) increased from 16 percent to 47 percent (Loveless, 2008).

There are differing perspectives on this important issue. Several reports and studies (Penner et al., 2015, Liang et al., 2012, Loveless 2008, Loveless 2012) suggest that taking Algebra I in eighth grade is not best for all students and thus should not be a universal requirement or even goal. These studies show that achievement has coincidentally decreased as the numbers of students enrolled in Algebra I in eighth grade has increased. However, there are other studies such as one from Spielhagen (2006) that shows positive effects of Algebra I during eighth grade.

Since the onset of this goal of eighth graders taking Algebra I, the mathematics landscape has changed. This change started with the introduction and adoption of the NCTM Standards in 1989 (Klein, 2003), and then the Common Core State Standards in 2010 (Austin et al., 2015). In addition, a basic search of course offerings indicate districts are now offering Algebra I at the seventh grade for an even more accelerated approach now with a large number of students taking Algebra I in eighth grade. The main motivation for having students complete Algebra I by eighth grade is to enable students to successfully complete a calculus course before finishing high school (Daugherty et al., 2017). Research from Clotfelter (2012) indicated as the number of students that accelerated into early Algebra I in either seventh or eighth grade increased, the pass rates of Algebra I decreased. Additional studies point to an increased number of underprepared students placed in Algebra I, as a form of acceleration, who end up having to retake Algebra I and tend to have no growth the second time completing the course (Fong, et al, 2014; Finkelstein, et al, 2012).

Rationale for Study

Many states have made completion of Algebra I in eighth grade a goal for students so that students have more course options at the high school level (Loveless, 2008). Studies regarding acceleration of math in middle school (i.e., complete Algebra I in eighth grade) have had mixed results. Some studies show positive effects for students who complete Algebra I by the end of eighth grade such as enrollment in more advanced mathematics courses and college attendance. Other studies show placing all students in Algebra I in eighth grade has negative effects such as many students having to retake Algebra I in ninth grade. The majority of these studies regarding acceleration and

Algebra I middle school specifically refer to students completing Algebra I in the eighth grade (Penner et al., 2015; Liang et al., 2012; Loveless, 2008; Mccoy, 2005; Smith, 1996; Spielhagen, 2006). However, little research has examined outcomes for students that complete Algebra I in the seventh grade. Xin Ma (2005) has conducted longitudinal studies that included seventh graders taking Algebra I. Ma studied the effects early acceleration of students in mathematics had on achievement, coursework, self-esteem, attitudes and anxiety. In this study, Ma points to higher rate of growth among accelerated students compared to students who are considered non-accelerated in groups of gifted, honors, and regular students. However, this growth showed inequities among different gender and racial groups.

Purpose

As mentioned, a goal of Algebra for All was to provide equity for low-income students and students of color and for becoming more competitive at the international level (Loveless, 2008). This study seeks to see if that has been the case for one Midwest district as the enrollment in Algebra increased in grades 7 and 8.

The purpose of this quantitative study is to identify and evaluate demographic and academic patterns of students placed in early acceleration at the middle school level looking at the continuation of acceleration, higher achievement, and an increase in the number of students successfully completing calculus by their senior year within a suburban Midwest public school district. Early acceleration at the middle school level is defined as completing Algebra I in seventh grade.

Research Questions

The following critical questions examine the patterns of acceleration continuation, course choices, and achievement, for students who completed Algebra I in seventh grade.

1. Based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015-2020, what are the student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
2. As the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020, what were the student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
3. How did student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e.,, gender, ethnicity, SES) compare between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years 2015-2020?

Hypothesis

H_0 1: There are no significant student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) that exist based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years of 2015 and 2020.

H_0 2: There are no significant student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) as the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020.

H_0 3: There are no student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e.,, gender, ethnicity, SES) when comparing between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years of 2015 and 2020.

Theoretical Foundation

Piaget's (1967) theory of cognitive development discusses the stages in which children move through as they grow and gain new abilities to process information. During the years a student would be approaching or in middle school, he/she is transitioning from the concrete stage to the formal operations stage. In the concrete stage, a student is "...concerned only with reality itself and, in particular, with tangible objects that can be manipulated and subjected to real action" (Piaget, 1967, p.62). As a student moves into the formal stage, they are able to think more logically and abstractly (Piaget, 1967; Blake & Pope, 2008). This transition is important in a student's ability to make sense of algebra. Susac et al. (2014) points out that Algebra I is typically the first experience a student has with abstract mathematical reasoning and the development of this algebraic thinking does not happen overnight. It is a process students must go through in order to be ready for the abstractness of algebra.

In addition to Piaget, Vgotsky's theory of Zone of Proximal Development (ZPD) discusses the importance of the social aspect of learning (Blake & Pope, 2008). The ZPD involves a teacher or peer who provides instruction or assistance in the learning of a new concept. This process is done through person-to person followed by individually internalizing information. Vgotsky (1986) also had thoughts regarding the delivery of algebra and suggested algebra concepts be presented to students at an earlier age in order for the "...new, higher concepts, in turn, transform the meaning of the lower. The adolescent who has mastered algebraic concepts has gained a vantage point from which he sees concepts of arithmetic in a broader perspective" (p. 202).

Pressey (1949) believed acceleration of bright students would allow those students to gain positive life outcomes earlier and get more out of life by entering their chosen professions at an earlier age. Most recently, several of these researchers have put together a report on acceleration that synthesizes the research of over 30 experts in the field of acceleration that theorize and find evidence that acceleration is the most effective intervention for high performing students (Assouline et. al, 2015; Colangelo et. al, 2004).

Nature of Study

This quantitative study examines high school seniors from a public suburban school district in the Midwest region of the U.S. The study includes data for a six-year period. The seniors of interest in the study are those that enrolled in Algebra I their seventh grade year along with the students who were enrolled in Algebra I in eighth and ninth grades. The courses they continued to take will be evaluated and noted if acceleration was continued. Algebra I EOC performance along with ACT Mathematics performance will be used to look at achievement. Patterns regarding student demographics will be examined. Demographics will include gender, ethnicity, and socio-economic status and will be compared throughout the years of students enrolled in Algebra I in seventh, eighth, and ninth grades. Patterns will be examined regarding courses taken and academic performance.

Delimitations

The delimitations of this study are student schedules will be evaluated from one Midwest, suburban school district with an enrollment of 17,794 students as of May 2020. The district is 82.8% white and 17.2% minority. The study will only look at coursework enrolled in and completed by seniors for the last six years, 2014-2020. Student data in the study will only be evaluated if a student was enrolled in Algebra I during seventh, eighth, or ninth grade. The demographical patterns will be only those of the district.

Significance of Study

This study is significant due to the ability to fill gaps in the research regarding the effects of early acceleration of students into Algebra I in seventh grade. This is an area that has not been addressed adequately in the literature to date. The study's findings will be of interest to school administrators of districts, as well as all district stakeholders, considering optimality of their acceleration policies in mathematics. The results should also be of interest to education policy makers. It is also envisioned that the study will spur follow-up studies regarding mathematics acceleration in the middle school, including how student attitudes and mindsets affect their course choices at the high school level and beyond.

CHAPTER 2

REVIEW OF LITERATURE

The focus of this literature review is to examine research surrounding the acceleration of gifted or bright students. This will include the effect acceleration has on achievement along with social-emotional factors. Much research points to the positive effect of overall acceleration for gifted students. In addition, practices and studies focused on the specific acceleration in mathematics, particularly in middle school with algebra will be discussed. There are two competing schools of thought regarding acceleration as the push for Algebra for all students in eighth grade has resulted in studies showing both positive and negative effects. The reasoning behind the algebra for all movement will be discussed.

Acceleration of Gifted Students

When looking at the acceleration of students in the educational setting, it is important to consider the history of acceleration and varying perspectives across time to see how the current state of acceleration evolved. Of course, many studies have been completed pertaining to the effects of acceleration on students. These studies will be discussed along with a list of acceleration practices.

Acceleration has long been a discussion surrounding high performing and gifted students. Acceleration was historically defined by Pressey (1949) who first asked and sought to inform the question:

> How may educational programs best be made so adjustable to differences in maturity and abilities that the mature and able may move more rapidly than the

> less mature through their training and into their adult careers if acceleration seems desirable? (p.1)

At that time, a longer school year or moving through curriculum faster was considered to be acceleration. Pressey then defined acceleration as, “progress through an educational program at rates faster or ages younger than conventional” (p. 2). Rogers (1992) presents the definition of acceleration as “any program adaptation that shortens the time gifted students must remain in a grade-progressive educational setting or advances the level of curriculum attained in a given time.” Currently, the National Association for Gifted Children (NAGC, 2004) defines acceleration as “allowing a student to move through traditional educational organizations more rapidly, based on readiness and motivation” (para. 1).

Acceleration of students has been a part of the U.S. education system for well over a century. In fact, the acceleration of bright students dates back to early U.S. history with education happening at home via tutors in the 1700s or in one-room schoolhouses in the 1800s. These settings allowed students to receive individualized instruction at an appropriate pace for the student’s ability (Colangelo, et al., 2004). In 1888, during a meeting of the National Education Association, Harvard President, CW. Eliot delivered an address voicing concern over the increasing age of newly admitted students to the university. Eliot saw a need for students to be accelerated in order to enter university at an earlier age (Pressey, 1949). Multiple studies in the years that followed found younger able students were performing better at the college or university level and dropped out at a lower rate than their older peers (Holmes, 1913, Jones, 1916, Pittenger, 1917, Husband, 1923).

The Superintendent of St. Louis Schools from 1867-1880 is credited with creating the first acceleration plan for students who showed the ability to move through coursework at a more advanced rate. From this work, came additional plans throughout the U.S. including the North Denver and Pueblo plans which provided more extended, intensive, and individual work for brighter children (Van Sickle et al., 1911). Over the years, acceleration has taken on different forms from combining years of work into fewer years, skipping grades, shortening time, credit by examination, Advanced Placement program, etc. Additionally, the conversation regarding students' social-emotional well-being entered the world of academic acceleration. (Passow, 1996).

Types of Acceleration

Southern and Jones (2004) discuss eighteen different acceleration types and the overlapping dimensions they possess. Some of the acceleration types are more widely used than others. The list developed by Southern and Jones include: 1) early admission to kindergarten, 2) early admission to first grade, 3) grade-skipping, 4) continuous progress, 5) self-paced instruction, 6) subject-matter acceleration/partial acceleration, 7) combined classes, 8) curriculum compacting, 9) telescoping curriculum, 10) mentoring, 11) extracurricular programs, 12) correspondence courses, 13) early graduation, 14) concurrent/dual enrollment, 15) Advanced Placement (AP), 16) credit by examination, 17) acceleration in college, and 18) early entrance into middle school, high school, or college. The dimensions that are taken into account with acceleration are pacing (rate of instruction); salience (the extent to which the acceleration is noticeable); peers (concern over the separation from peers through acceleration); access (how accessible the program is to students); and timing (the age of the accelerating student). All of these dimensions have legitimate impacts on a student's success in an acceleration program.

Over the years, studies regarding the acceleration of students sought to answer several questions identified by Kulik (2004) such as:

> What areas of a child's life are affected by a program of acceleration? Does acceleration affect a student's academic achievement, concept of self, extracurricular activities, or social adjustment? Are effects in these areas positive or negative? How large are the effects? (p. 13)

Kulik (2004) studied the effects of acceleration through a meta-analytic study which examined 26 different reports regarding acceleration. Kulik found acceleration to have an average effect size of 0.80 when looking at same-age groups. It is important to note that Kulik found there to be no difference and in fact a negative effect size comparing accelerated students to their older-aged peers. However, the difference was very small and can be concluded that accelerated students performed as well as older-aged peers. The effect size of accelerated same-age groups of 0.80 shows the value of acceleration for students (Kulik, 2004).

Colangelo et al. (2004) discusses the need for providing accelerative experiences for bright students. The research they have reviewed shows positive results for accelerated students in many areas. Accelerated students go on to receive more graduate degrees than their peers, feel more socially accepted, and feel more academically challenged. Generally, students appear to experience satisfaction from being accelerated. Several meta-analyses studies and reviews of research over the years have shown acceleration has a positive effect on students both academically and socially throughout their educational years and beyond (Kulik, 2004; Robinson, 2004; Rogers, 2044; Steenbergen-Hu et al., 2016).

In looking at the different types of acceleration, Rogers (2007, 2015) studied the effects of different acceleration options and found the effect size of subject acceleration to be 0.42-0.59 and compacted curriculum to have a 0.83 effect size for math or science. Rogers' research covered studies dating back to the late 1800s. Reis et al. (1998) studied curriculum compacting and found 24-70% of curriculum can be eliminated through the use of compacting for high performing students.

John Hattie (2009, Corwin, 2020) has studied the effect sizes of different practices in education. To date, he has examined over 1600 meta-analyses, including 95,000 studies, with regard to what works in education. According to Hattie, an effect size of 0.4 has shown to make a notable difference in a student's success in education. This is representative of a year's growth for a student. Hattie (2009, Corwin, 2020) reports acceleration programs have an effect size of 0.68 and ability grouping has an effect size of 0.30.

A specific focus for this study is on ability grouping, early grade acceleration, content acceleration, and grade skipping. Ability grouping has been defined by Steenbergen-Hu et al. (2016) as having three key features:

> (a) it involves placing students into different classrooms or small groups based on their initial achievement skill levels, readiness, or abilities; (b) the main purpose of such placement is to create a more homogeneous learning environment so that teachers can provide instruction better matched to students' needs and so that students can benefit from interactions with their comparable academic peers; and

> (c) such placements are not permanent school administrative arrangements that lead to restrictions on students' graduation, destination, or career paths (pp. 850-851).

Various studies have shown ability grouping has a positive effect on students' social self-concept of acceptance along with more interest in school and better student-teacher relationships. In addition, evidence suggests that ability grouping has a significant positive impact on academic achievement in the positive (Steenbergen-Hu et al., 2016; Vogl & Preckel, 2014). Vogl and Preckel (2014) researched 99 sets of ability matched "statistical twins", in regular classes and special classes for gifted students. Through multivariate analysis of covariance, they found cognitive ability had little effect while being placed in a gifted class had positive effects on self-concept and overall school experience.

Steenbergen-Hu et al. (2016) performed two second-order meta-analysis that spanned over 100 years and considered 13 meta-analyses. The focus was on four different ability grouping types. The research showed between class grouping had a small effect size of 0.04 to 0.06. This type of grouping involved created same grade level classes based on ability. Within class-grouping had an effect size of 0.19 to 0.30. These groups are formed within a class to create small groups. The next type of ability grouping is cross-grade and had an effect size of 0.26. Cross-grade grouping places students together across grades based on achievement or learning potential. The type of ability grouping with the highest effect size of 0.37 was special grouping. This grouping includes special programs or classes for gifted students such as "pull out" classes.

Loveless (2013) distinguishes between ability grouping and tracking. Tracking is similar to between-class grouping as defined by Steenbergen-Hu et al. (2016). Loveless described ability grouping as akin to the within-class grouping typically done at the elementary level. Using NAEP data from 1990 to 2011, Loveless found both ability grouping and tracking have been popular practices in the last two decades and despite criticism, effects of both practices have continued to be positive for students.

Another type of acceleration that is discussed frequently in the literature is grade skipping. Many research studies show this method proves to be successful for bright students (Kuo & Lohman, 2011; Lubinksi et al., 2001; McClarty, 2014). Lubinski et al. (2001) performed a longitudinal study of 320 extremely gifted students over a period of 10 years from early adolescence to early adult years. The authors found that 95% of these students experienced some form of acceleration during their education. Of that 95%, 49% grade skipped as a form of acceleration. Advanced subject-matter placement was the most frequently reported at 82% of the students who had received some type of acceleration during their education. In the study, 71% of the students reported a satisfactory experience. Further, those that did not express a satisfactory experience cited a desire for more acceleration. The participants expressed positive views about their acceleration along multiple dimensions including academic, social (getting along with intellectual peers and adults), personal growth, and acceptance of self.

Kuo and Lohman (2011) looked at the effect demographics had on whether students grade skipped along with the effects on achievement in high school of the grade-skipping that occurred during elementary and/or middle school. The study included 236 participants and showed females, whites, and students with high socioeconomic status were more likely to skip grades early in primary school years. Kuo and Lohman found students who skipped a grade earlier on in elementary school were more successful than those who skipped in upper grades.

McClarty (2015) studied 105 accelerated students who had grade skipped and matched them with nonaccelerated students of similar demographics and achievement levels. McClarty looked at academic performance on PSAT, SAT, and ACT scores and high school and college GPAs. In addition, the extent to which students took advantage of educational opportunities was compared. Accelerated students participated in advanced coursework in eighth grade and Advanced Placement courses in high school at a higher rate than their nonaccelerated peers. McClarty found students who had grade skipped significantly outperformed their nonaccelerated peers on the PSAT, SAT, and ACT.

Content or subject-based acceleration has shown to be beneficial for students who excel in a particular subject such as language arts or mathematics. Studies show students who are grouped by ability and accelerated at an early age in language arts and mathematics experience positive gains in their performance throughout their schooling in addition to viewing their educational histories as positive and most would prefer to be accelerated more not less (Gavin et al., 2009; Gavin et al., 2007; Rogers, 2004; Wai, 2015). Content or subject-based acceleration leads to a discussion regarding acceleration specifically in mathematics.

Mathematics Acceleration

Stinson (2004) discusses mathematics as a gate-keeper for students and the importance of mathematics being a subject that is available to all students despite ability.

Stinson asks whether inclusive mathematics empowerment ends the ability sorting of elementary-aged students? Many researchers cite the advantage of accelerating mathematically gifted students as well as average skilled students (Burris et al., 2006; Dougherty et al., 2017; Lubinski & Benbow, 2006; Ma, 2005).

Tracking is a common practice in accelerating mathematics. Loveless (2013) describes tracking as being in different classes based on ability, typically done in middle and high school, and increases in middle school and peaks toward the end of high school. Historically, there has been a lot of criticism over tracking, particularly in the 1970s and 1980s due to concern over race and class. In the 1990 several groups spoke out against tracking which led to a detracking movement. However, tracking is on the rise again (Loveless, 2013).

Domina et al. (2019) examined 20,000 eighth graders in 23 public middle schools and the effects of tracking in mathematics. Results indicated that schools with tracking had lower levels of mathematical achievement growth and this was even more evident with low-achieving students. Additionally, schools who made efforts to detrack by enrolling all students into accelerated courses also saw negative effects.

A study conducted by Boaler et al. (2000) followed 48 students who were moved into a tracked setting. Over 80% of the students reported the new setting had negative effects on them both academically and in their attitudes towards mathematics. This was the case whether students were in a low or high leveled class. Several other studies (Ventakatakrishnan & Wiliam, 2003; Ireson & Hallam, 1999, Gamoran, 1992) point to the idea that while tracking may benefit high achieving students, inequality increases due to low achieving students not making the same gains.

A longitudinal study by Ma (2005), examined at math achievement and growth of students classified as gifted, honors, and regular who all took part in an accelerated mathematics program. The students were all accelerated by completing Algebra I in either seventh or eighth grade. Ma compared these students with nonaccelerated students. The results of the study suggest the largest advantage was for the students who were classified as regular ability students. In addition, acceleration had the largest impact on white and male students. Finally, regular students with low socioeconomic status who were accelerated grew at a faster rate than accelerated high socioeconomic students.

Lubinski and Benbow (2006) conducted 35 years of longitudinal research with 5 cohorts from the Study of Mathematically Precocious Youth (SMPY). The finding of the research discusses the importance of appropriate opportunities and differentiation of mathematically gifted students to ensure long term career satisfaction and involvement in science, technology, engineering, and mathematic (STEM) careers. The study showed of the highest performing students, over 40% earned a doctorate degree, 55% earn more than the median of their same gender, approximately 7% developed patents, and 3% earned tenure at a top 50 U.S. university.

A study conducted by Burris et al. (2006), reviewed the effects of providing an accelerated curriculum to all students, sixth through eighth grade students in heterogeneous settings. The curriculum allowed for three years of content to be taught in two years (sixth and seventh grade). The ninth grade course, Mathematics I was taught in eighth grade. The results of the study showed an increase in the completion of advanced courses in high school overall especially for minority and low socioeconomic students.

Overall test scores improved with 90% of students passing the Mathematics I Regents Exam and 100% meeting or exceeding the district's graduation standards.

Dougherty et al. (2017) also looked at accelerating all students regardless of ability level in middle school. The study came after a district sought to provide access to rigorous math courses for all students. With the implementation of new policies, the district went from 40 percent enrolled in accelerated math to 70 percent. A longitudinal study of students from grade 5 through high school was conducted. The results of this study suggested an increase in the number of students completing precalculus, especially among females and students of low socioeconomic status. The study also found that students who were intending to enroll in a four year college increased by 25 percentage points. The researchers concluded that the acceleration of low-skilled students increased college readiness.

The previously discussed studies and others focus their attention on eighth grade Algebra I, a course typically designed for ninth grade as the main form of acceleration in mathematics. Many studies, policies, and position papers have emanated from the practice of accelerating math in eighth grade.

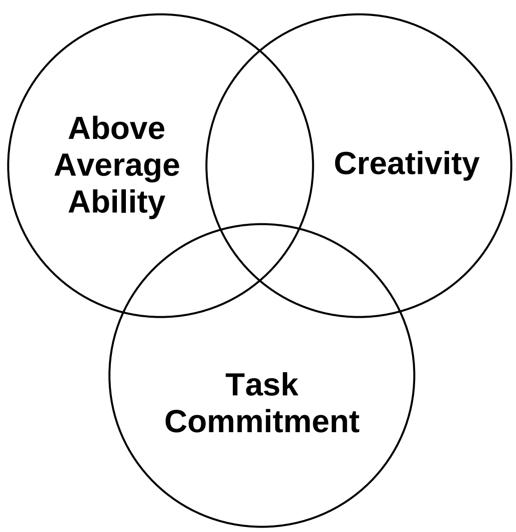
Acceleration Criteria

Renzulli and Gaesser (2015) offer research-based recommendations for identifying students who would be considered gifted in mathematics as well as other areas. Identification should not be a one-time, one-hour glimpse of a student's ability and/or potential. Instead, a more complete picture of a student is recommended using multiple measures. These measures should be aligned with the overall intent of the accelerated or gifted program. For math, this is best accomplished through mathematics testing, previous grades, and teacher recommendations on skills and motivation.

Renzulli and Gaesser (2015) propose a three-ring conception of giftedness (see Figure 1). These rings are interrelated and include above average ability, task commitment, and creativity. Above average ability "...encompasses both general and specific performance areas and is the most constant of the rings" (Renzulli & Gaesser, 2015, The Three-Ring Conception of Giftedness section). Task commitment represents a student's perseverance, determination, or grit. Students will task commitment are motivated by a problem and are willing to devote time and energy in working through the problem. The creativity ring is made up of a group of traits including curiosity, ingenuity, and willing to challenge convention and tradition. In mathematics, this creativity leads students to have exceptional problem solving skills (Renzulli & Gaesser, 2015).

Figure 1

Three-Ring Conception of Giftedness



Additional researchers (Assouline & Lupkowski-Shoplik, 2011; Gavin, 2005) emphasize the importance of looking at several variables when identifying students for accelerated programs designed for gifted or promising mathematics students. Gavin (2005) discusses the recommendation of the National Council of Teachers of Mathematics' Task Force on the Mathematically Promising (Sheffield, 1999) of using the label of "promising students" in determining students who are ready for acceleration. To say a student shows mathematical promise is defined as "...a function of ability, motivation, belief, and experience or opportunity" (Gavin, 2005, p. 25). When looking at ensuring all students are represented as a diverse population in accelerated programs, researchers (Assouline & Lupkowski-Shoplik, 2011; Gavin, 2005; Renzulli & Gaesser, 2015) have shared using multiple variables to discover mathematical talent helps to include all students.

Knowing the multiple variables needed for determining eligibility for an accelerated program is only the first step. Determining the measurements to use is key to a successful identification process (Renzulli & Gaesser, 2015). A standardized test measures what a student has learned and results allow educators to compare a student's progress to other students. A standardized test can help to determine instructional needs as well (Renzulli & Gaesser, 2015). Examples of a standardized test could be the Iowa Test of Basic Skills (ITBS), the Scholastic Aptitude Test (SAT) and the American College Test (ACT) (Assouline & Lupkowski-Shoplik, 2011; Gavin, 2005).

A cognitive/ability test measures areas of verbal comprehension, abstract reasoning, problem solving or working memory. These tests give what is typically known as an IQ score. Long standing research shows students at the 98th percentile in IQ are in need of work that is as much as 2 grade levels above their current grade. However, this measurement along does not give a clear picture of what a student is truly ready for and their programming needs (Assouline & Lupkowski-Shoplik, 2011)

An aptitude test measures the potential for future performance. Typically, when using an aptitude test for determining eligibility into an accelerated program, it is common practice to administer a test that is designed for older students. This allows educators to determine if a student is ready for the more advanced material (Assouline & Lupkowski-Shoplik, 2011). An example of an aptitude test is the Iowa Algebra Aptitude Test (IAAT). The test measures algebra readiness and is intended for students in grades 7 through 8. It can be used on younger students to see if they are ready for algebra concepts at an earlier age (Assouline & Lupkowski-Shoplik, 2011).

A final measurement is one of a teacher rating. The most recommended teacher rating scale is the Scales for Rating the Behavioral Characteristic of Superior Students (SRBCSS) (Renzulli et al., 2009). A teacher rating allows for teachers to rate behaviors regarding mathematics of students. Students who may not test well or score in the high percentiles may still show promise in their creativity and task commitment. This can be shown through a teacher rating scale (Renzulli & Gaesser, 2015). In an effort to continue to be fluid and ongoing as Gavin (2005) recommends, it is important to monitor students regularly for identification and continued success.

Eighth Grade Algebra

Loveless (2008), from the Brown Center, reports that in the late 1990s, the Clinton administration called for an increase in the number of students enrolled in eighth grade Algebra I. This was further encouraged by Robert Moses with his "Algebra Project" initiative. Additionally, the standards reform movement led by the National Council of Teachers of Mathematics prompted school to examine policies that historically had restricted the acceleration of algebra into eighth grade (Spielhagen, 2006)). As original writers of the NCTM *Curriculum and Evaluation Standards for School Mathematics,* Thompson and Rathmell (1988) point out a focus of these original standards was readiness concepts for algebra including functional relationships. It is also noted in the standards that a students' computational fluency should not prevent students from studying any mathematical concepts. Both of these aspects encourage more students studying algebra at a possible earlier age.

Loveless (2008) reports in the 10 years from 1990 to 2000, the number of students that enrolled in Algebra I in eighth grade in the U.S. increased from 16 percent to 24 percent. Several states then mandated enrollment of all eighth grade students in Algebra I. The movement was motivated by falling test scores in international assessments and a desire to provide equity among students. Loveless discusses data that suggests that while the U.S. scores have increased steadily on international assessments since the push for eighth grade Algebra I, initial successes have been followed by an increasing number of students struggling in advanced math classes. Additional studies have supported these findings.

Smith (1996) studied students who had early access to algebra in eighth grade. The study suggests students who had early access to Algebra I were more likely to take advanced math courses and be successful in those course. However, Smith noted access to Algebra I in eighth grade was not equitable as there were disproportionate numbers of low socioeconomic students enrolled in the eighth grade algebra course. Smith makes recommendations for curriculum policy regarding the timing of algebra for all in order to be a more inclusive opportunity for students.

Spielhagan (2006), discusses the positive effect of eighth grade algebra that occurred in the earlier years of the “Algebra for All” movement. Spielhagan points to several studies (Smith, 1996; Assouline & Lupkowski-Shoplik, 2005) that discuss the importance and value of providing algebra to eighth grade students. Spielhagan studied a large southern school district, looking at 2,634 graduating seniors who had either been selected for eighth grade algebra or had taken algebra as a ninth grader. Students with similar prior math achievement were examined. The study showed students who took algebra in eighth grade stayed in the advanced math pipeline longer. It was also determined that more students who studied Algebra I in eighth grade had a higher college attendance rate.

In contrast, Liang et al. (2012) studied California’s movement toward eighth grade Algebra for all. The study looked at approximately 625,000 eighth grade students who took the California Standards Tests (CST) for Algebra I during the years of 2003-2008. The number of students performing at a proficient level or above increased with the number of students taking the assessment increasing. However, the number of students enrolling in advanced math classes decreased as the students moved into high school’s more advanced math courses. It is noted that the original purpose behind eighth grade Algebra was to allow students the opportunity to take more advanced math courses. However, in this study, it showed only approximately 330,000 ninth grade students (53% of the original students who took Algebra I) took the geometry CST; 308,000 10th grade students (49% of the original students who took Algebra I) taking the Algebra II CST; and 299,000 11th grade students (48% of the original students who took Algebra I), taking the summative high school math CST.

In research done by Clotfelter et al. (2012) for the National Bureau of Economic Research, ten North Carolina Districts were examined for the effect of algebra in eighth grade over a five year period from 1999 to 2004. In looking at the likelihood of students taking further advanced math courses after a district pushed eighth grade algebra placement, they found students scored lower on the end-of-course exams and were less likely to enroll and be successful in Geometry and Algebra II. Clotfelter et al. (2012) also showed there was a higher percentage of students in eighth grade as opposed to higher grades that had to re-take Algebra.

Penner et al. (2015) conducted another study on California's push for eighth grade algebra for all students. One large district that enrolls approximately 4000 eighth grade students was examined. The study included four years of data regarding math course enrollment at the eighth grade level. The study compared Algebra for All schools with Baseline schools. Using a distributional approach, the findings showed Algebra for All in eighth grade was not successful regarding student achievement. In fact, students tended to be less successful when schools began to adopt algebra for all. Penner et. al (2015) found, "students in the 60th to 85th percentile from Algebra for All schools are scoring about a third of a standard deviation lower than the students in the 60th to 85th percentile from Baseline schools" (p. 12)

It appears throughout this research there has been a shift in the success of acceleration in mathematics at the middle school level. The shifts seem to have appeared around the year 2010. It is important to note that this is the time when the Common Core State Standards were first released.

Recommendations

NCTM was founded in 1920 and is the largest mathematics education organization. NCTM works to provide research-based guidance and resources for quality mathematics instruction. As stated above, NCTM first wrote voluntary national mathematics standards for K-12 education in 1989 and again in 2000 with the intention to impact mathematics education in a way that created more comprehensive and complete mathematics programs throughout the U.S. These standards prompted states to begin writing their own standards in mathematics (NCTM, 2020).

More recently, NCTM (2016) released a position statement regarding opportunities for students with exceptional mathematical promise. In this statement, NCTM emphasized the importance of making opportunities available to all students who show exceptional mathematical promise. These students do not just include those identified through traditional assessments, but includes students who have an exceptional high interest in mathematics. According to NCTM (2016) students who have exceptional interest in mathematics

> "are eager to try more difficult problems or extensions or to solve problems in different, creative ways; are particularly good at explaining complex concepts to others or demonstrate in other ways that they understand mathematical material deeply; and/or are strongly interested in the material" (NCTM, 2016, para. 3).

NCTM (2016) recommends that students with exceptional mathematical promise be offered multiple opportunities to develop their mathematical skills. Regarding acceleration, NCTM recommends opportunities to be available to all students with exceptional promise and emphasizes the importance of critical concepts not being rushed or skipped. Students should have an opportunity to explore mathematics in depth and continue to do so through high school.

The Common Core State Standards in Mathematics were released in June 2010 by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) in an attempt to create learning standards and expectations that were consistent across states (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO, 2010). These standards were meant to help students become more college and career ready with standards that were:

> Fewer, clearer, and higher, to best drive effective policy and practice; aligned with college and work expectations, so that all students are prepared for success upon graduating from high school; inclusive of rigorous content and applications of knowledge through higher-order skills, so that all students are prepared for the 21st century; internationally benchmarked, so that all students are prepared for succeeding in our global economy and society; and research and evidence-based (NGA & CCSSO, 2010, para.2)

A goal of the CCSS in mathematics was to focus on specific work at each grade level. While this allows teachers to go deeper with students on mathematical concepts, the repetitive nature of many old state standards was no longer evident. There is more coherence and rigor in the CCSS involving conceptual understanding, procedural skills and fluency, and application.

Prior to the implementation of CCSS, in a study of mathematics textbooks, material in eighth grade was 70% review and only 30% new (Flanders, 1987). This created a common practice to skip grade-level content in middle school for acceleration. With the new CCSS, mathematics material builds from one grade to another. Acceleration through skipping grade-level content then results in missing vital concepts and skills. In a study released by ACT (2012), 95% of the material considered most important as a prerequisite for success in first-year college mathematics courses is taught prior to grade 7 and up to Algebra I and 45% is taught in grade 7 or earlier. This information reinforces the notion that skipping grade-level content in middle school leads to missing out on key mathematical concepts.

In California, where there was a large push to have Algebra for all, the implementation of CCSS has caused the state to reexamine the policy of all students in Algebra I in eighth grade. A new Algebra I class is more demanding than previous versions of the course. Policy and curriculum writers must look at course planning included all content in order to ensure students have a solid understanding and are not having to retake Algebra I (California Department of Education, 2015).

The Achieve Pathways Group along with the CCSS mathematics writing team worked together to create guidelines for acceleration in mathematics starting in middle school with the recommendation that compacted courses are the best way to accelerate students in mathematics ensuring no content is skipped (NGA & CCSSO, 2010). The guidelines are as follows:

1. Compacted courses should include the same Common Core State Standards as the non-compacted courses. It is recommended to compact three years of material into two years, rather than compacting two years into one. The rationale is that mathematical concepts are likely to be omitted when trying to squeeze two years of material into one. This is to be avoided, as the standards have been carefully developed to define clear learning progressions through the major mathematical domains. Moreover, the compacted courses should not sacrifice attention to the Mathematical Practices Standard.
2. Decisions to accelerate students into the Common Core State Standards for high school mathematics before ninth grade should not be rushed. Placing students into tracks too early should be avoided at all costs. It is not recommended to compact the standards before grade seven. In this document, compaction begins in seventh grade for both the traditional and integrated (international) sequences.
3. Decisions to accelerate students into high school mathematics before ninth grade should be based on solid evidence of student learning. Research has shown discrepancies in the placement of students into “advanced” classes by race/ethnicity and socioeconomic background. While such decisions to accelerate are almost always a joint decision between the school and the family, serious efforts must be made to consider solid evidence of student learning in order to avoid unwittingly disadvantaging the opportunities of particular groups of students.
4. A menu of challenging options should be available for students after their third year of mathematics—and all students should be strongly encouraged to take

> mathematics in all years of high school. Traditionally, students taking high school mathematics in the eighth grade are expected to take Precalculus in their junior years and then Calculus in their senior years. This is a good and worthy goal, but it should not be the only option for students. Advanced courses could also include Statistics, Discrete Mathematics, or Mathematical Decision Making. An array of challenging options will keep mathematics relevant for students, and give them a new set of tools for their futures in college and career. (NGA/CCSSO 2010, p. 81)

Summary

Over the years there have been many studies regarding the acceleration of students who show abilities above the current instruction level. For the most part, general acceleration practices have been successful for gifted and bright students in the areas of academics, college and career plans, and social-emotional factors. When discussing math acceleration, it is mostly a tool used for acceleration in middle school via earlier enrollment in the Algebra I course. Some states have had an Algebra for all policy with the goal of having all eighth grade students complete Algebra I. Earlier studies showed accelerated students were successful in future mathematics courses.

Upon the implementation of the NCTM Standards in 1989 and 2000 and subsequently CCSS in 2010, the material studies in a typical Algebra I class changed and it became more rigorous and demanding. Recent studies show students are not as successful after taking an Algebra I in eighth grade. Recommendations for identifying students for acceleration by more than just traditional assessments along with compacting curriculum instead of grade-level content skipping have become more common practice.

CHAPTER 3

METHODOLOGY

Little research to date examines students that accelerated mathematics education by completing Algebra I in seventh grade. This study seeks to examine the patterns that occur when skipping grade-level content, followed by enrollment in Algebra I in seventh grade, in order to accelerate mathematics to allow for completion of calculus by graduation. The patterns of interest in this study are the type and number of advanced courses students take in high school, and achievement on Algebra I EOC and ACT Mathematics of students who were enrolled in seventh grade Algebra I compared to students who were enrolled in eighth and ninth grade Algebra I along with demographic patterns.

Research Design

The quantitative research design of this study is a longitudinal trend design. Quantitative research, or positivist research, seeks to "describe and explain features of reality by collecting numerical data on observable behaviors of samples and by subject these data to statistical analysis" (Gall et al., 2007, p.650). Gall et al. (2007) describe a longitudinal study as one in which data is collected at different points in time "...in order to study changes or continuity…" A longitudinal study can be one of four designs: trend, cohort, panel and cross-sectional. A trend design looks at different samples at different data-collection points. This study examined different groups of students and their demographics at separate six-year intervals to examine the types of advanced mathematics courses taken after enrollment of Algebra I in seventh, eighth, and ninth grades, and achievement on Algebra I EOC, and ACT Mathematics.

Descriptive and comparative analyses were used to examine patterns of course completion and achievement among and between groups of students enrolled in Algebra I in grade seven, eight, and nine in the graduation years of 2014-2020. Descriptive and comparative attention were given to demographic information including gender, race and socio-economic status.

When discussing the patterns of enrolling in Algebra I at different grade levels regarding course selection and completion, Algebra I EOC and ACT Mathematics achievement, and college attendance, descriptive statistic and ANOVA analyses were utilized.

A possible threat to internal validity is how students were originally selected for acceleration. Throughout the years of the study, the procedures for identifying students to be enrolled in Algebra I in seventh grade did not remain constant. This would cause students to not have comparable ability at the onset of each 6-year interval. There would be an operational definition threat to external validity in this study due to different school districts' course offerings.

The independent variable in this study is the grade-level in which a student is enrolled in Algebra. The dependent variables include the courses students enrolled in after taking Algebra I in seventh, eighth, and ninth grade. The courses were defined as traditional or advanced based on the District's course descriptions and prerequisites. These course descriptions can be found in Appendix B. In addition, the course pathways expected by the district can be found in Appendix C. Additional dependent variables include achievement on Algebra I EOC and ACT Mathematics, and student demographics.

Research Questions

1. Based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015-2020, what are the student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
2. As the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020, what were the student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
3. How did student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e.,, gender, ethnicity, SES) compare between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years 2015-2020?

Hypothesis

H_0 1: There are no significant student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) that exist based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015 and 2020.

H_0 2: There are no significant student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) as the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020.

H_0 3: There are no student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e.,, gender, ethnicity, SES) when comparing between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years of 2015 and 2020.

Population and Sample

An expedited IRB was submitted as part of human subjects' consideration. This study does not require any in person contact with students or staff. The data used for the study was accessed through the Student Information System (SIS) maintained by the district.

Participants in the study attended school in a Midwest suburb public school district. The study used a non-probability, convenience sample as the students were enrolled in the researcher's employed district. The district has been the fastest growing district in the state over the past 10 years, adding an average of 400-500 students per year with a current enrollment of approximately 18,000. There are currently 12 elementary schools, three middle schools, and three high schools. The district demographic composition is 84.3% White, 6.8% Black, 4% Hispanic, 2.9% Multi-racial, and 2%

Asian. Over the past nine years an average of 21.8% students qualify for a free or reduced lunch rate.

The students included in the study were placed in Algebra I in seventh, eighth, or ninth grade. The study examined 237 students enrolled in seventh grade Algebra I, 1634 students enrolled in eighth grade Algebra I, and 2841 students enrolled in ninth grade Algebra I. Course enrollment, along with achievement, was observed through graduation. Students enrolled in Algebra I in seventh grade completed an accelerated math course in sixth grade in which seventh grade standards were taught and sixth grade standards were skipped. After the accelerated math course in sixth grade, students were then placed in Algebra I in seventh grade, skipping eighth grade standards. These students then were enrolled in Geometry for eighth grade. Students enrolled in Algebra I in eighth grade skipped eighth grade standards and content and placed in Geometry during ninth grade.

In order for a student's data to be included in the study, the student would have been enrolled in Algebra I in seventh, eighth, or ninth grade and continued through to graduation within the same district. To have a complete record for all students, the study includes students who graduated between 2014-2020. This allows for all students to have completed their four high school years by May 2020. Data was collected using the district Tyler Student Information System (SIS) software identifying students who were enrolled in Algebra I in seventh, eighth, and ninth grade and examining their course schedules throughout high school to determine the type and number of mathematics courses in which the students enrolled, along with achievement on Algebra I EOC and ACT Mathematics. (Achievement scores are not available in the year 2020 due to

COVID-19 quarantine did not allow for testing.) The number of students in each group increased as the enrollment in the district increased.

Measures

The courses taken by students in the study can be described as traditional or advanced. These courses are described in the district course descriptions (see Appendix A). These descriptions are derived from curriculum writing done at the district level and overseen by the Director of Teaching and Learning. Curriculum is shared with teachers and used to guide instruction in all classes. Course descriptions are used in all high schools in the district by counselors and students to make course decisions resulting in a valid instrument for identifying courses and pathways.

Ratings were given for courses to represent the order in which they are taken and the level (low level, traditional, or advanced) of each course. Courses were coded as follows. The first digit represents the course order beginning with Algebra I and ending with Calculus BC. The second digit after the decimal represent the level of the course (4 = low level, 5 = traditional level, 6 = advanced level). Algebra I is the introductory course to the pathways and does not have a low level or advanced, giving it a rating code of 1.5. After Algebra II, students have multiple options of courses. These courses have also been coded according to level.

The expected college and career readiness pathway and ratings (see Appendix B and C) for students enrolled in Algebra I at seventh, eighth, or ninth grade are found in Table 1.

Table 1

Pathways and Ratings

Grade	Seventh Grade Algebra I Pathway	Rating	Eighth Grade Algebra I Pathway	Rating	Ninth Grade Algebra I Pathway	Rating
7^{th}	Algebra I	1.5				
8^{th}	Adv Geometry	2.6	Algebra I	1.5		
9^{th}	Adv Algebra II	3.6	Adv Geometry	2.6	Algebra I	1.5
10^{th}	Pre-Calculus	4.6	Adv Algebra II	3.6	Adv Geometry	2.6
11^{th}	Calculus AB	5.6	Pre-Calculus	4.6	Adv Algebra II	3.6
12^{th}	Calculus BC	6.6	Calculus AB	5.6	Pre-Calculus	4.6
Total		24.5		17.9		12.3

With the ratings given for courses, students who are enrolled in Algebra I in seventh grade and complete this path would have a total rating of 24.5 when all courses are added together. The study used comparative statistics to analyze the actual total ratings of all students who were enrolled in seventh, eighth, and ninth grade Algebra I as a percent of the expected rating. Students who complete the expected college and career readiness pathway would score a 100% no matter what grade level they started Algebra I. The average percent for each group of students (Algebra I starting at seventh, eighth, or ninth grade) was compared.

Internal consistency was used to determine the reliability of course ratings used in the study. Upon completing a measure of internal consistency on the course ratings, it is expected there would be a high correlation between groups.

The Missouri Algebra I EOC is developed by a team of educators and is administered by Questar Assessment, Inc. in conjunction with the Missouri Department of Elementary and Secondary Education. The Algebra I EOC is a graduation requirement as of 2014 in Missouri and measures students' progress towards the Missouri Learning Standards. The Algebra I EOC has gone through multiple years of reliability and validity testing. The most current results of this testing show the Algebra I EOC has a reliability coefficient of 0.88 and a standard error of measurement (SEM) of 3.26 for the Spring 2019 administration. Tests for reliability and validity date back 10 years for the Missouri Algebra I EOC. Scores are reported as a scale score as well as a level of achievement: below basic, basic, proficient, and advanced (DESE, 2020).

ACT (2019) describes their test as being "oriented toward the general content areas of college and high school instructional programs. The test questions require students to integrate the knowledge and skills they possess in major curriculum areas with the information provided by the test" (p. 1.1). Students receive a scale score anywhere from 1-36 on each section of the ACT in addition to a composite scale score. The latest reliability and validity testing show the ACT Mathematics portion to have a reliability quotient of 0.91 and a SEM of 1.55.

Procedures

Using Tyler Student Information System (2015), a comprehensive data warehouse for school districts that includes information such as assessment, attendance, course management, discipline, document management, enrollment, gradebook, etc., students are identified as having been enrolled in Algebra I in seventh, eighth, and ninth grade starting with graduation year 2014. Students are similarly identified through graduation year 2020.

The next step was to remove students who did not continue with the district through to graduation. Using Tyler SIS, students' mathematics courses were captured from seventh grade through 12th-grade along with demographic information. Using the course ratings found in Appendix C, each student received a rating for each mathematics course completed. Once ratings were assigned, each student received a score that is a sum of each course rating. Based on the recommended pathway, a student who was enrolled in Algebra I in seventh grade and continued as expected received a sum of 24.5. Each group of students, based on that group's year of enrollment in Algebra I received an average rating. Using Tyler SIS, students' scale scores on Algebra I EOC and ACT Mathematics was accessed through Assessment.

When looking at course ratings, achievement on Algebra I EOC and ACT Mathematics descriptive and comparative statistics using ANOVA and F-ratios to compare between and within groups will be used, paying attention to subgroups. Patterns over time was assessed between groups and subgroups.

Summary

The purpose of this study and research questions were reviewed in this chapter. In addition, a detailed explanation of the research design being utilized along with population details, sampling type, and data collection and analysis are included. The data collected in this study was used to answer the research questions and examine the course enrollment trends between groups initially enrolled in seventh grade Algebra I as well as compared to groups of students enrolled in eighth and ninth grade Algebra I including subgroup patterns over time.

CHAPTER 4

FINDINGS

An increase in enrollment in seventh grade Algebra I in a Midwest school district over a six-year time period from 2010 to 2015 prompted questions and research into patterns that may have resulted from this increased enrollment. Previous studies have shown positive and negative results for students who are accelerated early as well as a concern for students who are not given an opportunity to participate in higher level mathematics. Chapter four provides an analysis of the research and patterns regarding academics and demographics over a six-year time period.

The following research questions paved the way for analyzing the patterns found within the results.

1. Based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015-2020, what are the student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
2. As the number of students enrolled in Algebra I on seventh grade increased I graduating classes of 2015 through 2020, what were the student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?
3. How did student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e., gender, ethnicity, SES) compare between students enrolled in Algebra I in seventh grade

to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years 2015-2020?

The data and findings below will determine whether these patterns exist or if null hypotheses would be accepted.

Data Description

The sample consisted of a total of 4712 students from the graduating classes of 2015-2020 who were enrolled in Algebra I in either seventh, eighth, or ninth grade at a large, suburban, Midwestern, public school district. During the six-year period, there were 237 students enrolled in Algebra I in seventh grade, 1634 enrolled in eighth grade, and 2841 enrolled in ninth grade. Students included in the data set were enrolled in Algebra I and continued through to graduation. Data was collected through the district's Tyler Student Information System (SIS) and included demographics (gender, race, and socio-economic status), program and services (special education and gifted program), mathematics coursework, End of Course (EOC) performance, and ACT Mathematics performance. Data collected was organized into an Excel spreadsheet, checked for errors, then imported into Statistical Package for Social Sciences, Version 26 (SPSS) for frequency, descriptive, and inferential statistical analysis.

Course Pathway Completion Rates

Analysis of the data determined whether the null hypothesis for each research question had any validity. Each null hypothesis is represented below with the respective patterns and results.

H_0 1: There are no significant student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) that exist in the course pathway taken among students who took

Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015 and 2020.

Students were placed into groups based on the completion of a particular percentage of the expected course pathways in Table 1.

Table 1

Expected Pathways and Ratings

Grade	Seventh Grade Algebra I Pathway	Rating	Eighth Grade Algebra I Pathway	Rating	Ninth Grade Algebra I Pathway	Rating
7th	Algebra I	1.5				
8th	Adv Geometry	2.6	Algebra I	1.5		
9th	Adv Algebra II	3.6	Adv Geometry	2.6	Algebra I	1.5
10th	Pre-Calculus	4.6	Adv Algebra II	3.6	Adv Geometry	2.6
11th	APCalculus AB	5.6	Pre-Calculus	4.6	Adv Algebra II	3.6
12th	APCalculus BC	6.6	APCalculus AB	5.6	Pre-Calculus	4.6
Total		24.5		17.9		12.3

Assuming a student remained on these specific pathways, and took these exact courses, a student would complete 100% of the expected pathway. If a student fell short of a complete pathway they would have a lower percentage completion rate. Table 2 shows the percent completion rates that correspond to those examples.

Table 2

Expected Pathways and Ratings with Completion Percentages

Grade	Seventh Grade Algebra I Pathway	Rating	%	Eighth Grade Algebra I Pathway	Rating	%	Ninth Grade Algebra I Pathway	Rating	%
7th	Algebra I	1.5							
8th	Adv Geometry	2.6		Algebra I	1.5				
9th	Adv Algebra II	3.6	31.4	Adv Geometry	2.6		Algebra I	1.5	
10th	Pre-Calculus	4.6	50.2	Adv Algebra II	3.6	43.0	Adv Geometry	2.6	
11th	APCalculus AB	5.6	73.1	Pre-Calculus	4.6	68.7	Adv Algebra II	3.6	62.6
12th	APCalculus BC	6.6	100	APCalculus AB	5.6	100	Pre-Calculus	4.6	100
Total		24.5			17.9			12.3	

Note: %=Pathway completion if course is the last course a student enrolls in.

Students could also obtain different percentages of pathway completion by enrolling in courses other than those listed in the expected pathways. Table 3 shows examples of such students.

Table 3

Student Examples of Sample Pathway Course Rating and Completion Percentage

	Student A		Student B		Student C		Student D		Student E	
Grade	Course	Rating	Course	Rating	Course	Rating	Course	Rating	Course	Rating
7th	Algebra I	1.5								
8th	Adv Geometry	2.6	Algebra I	1.5			Algebra I	1.5		
9th	Formal Algebra II	3.5	Formal Geometry	2.5	Algebra I	1.5	Adv Geometry Adv Algebra II	2.6 3.6	Algebra I	1.5
10th	College Algebra/ Statistics	4.54	Formal Algebra II	3.5	Formal Geometry	2.5	Precalculus	4.6	Adv Geometry Adv Algebra II	2.6 3.6
11th	Precalculus	4.6	Algebra III	4.4	Formal Algebra II	3.5	AP Calculus AB	5.6	Precalculus	4.6
12th			College Algebra	2.275	College Algebra	2.275	AP Calculus BC	6.6	AP Calculus AB AP Statistics	5.6 5.5
	Total	%	Total	%	Total	%	Total	%	Total	%
Pathway Completion	16.74 out of 24.5	.68	14.175 out of 17.9	.79	9.775 out of 12.3	.79	24.5 out of 17.9	1.37	23.4 out of 12.3	1.90

Students were then put into groups based on the amount of their pathways completed. These pathway completion groups, based on students completing the expected level of coursework based beginning with the grade level enrolled in Algebra I, were used to compare grade level groups, along with demographic groups. Table 4 describes these pathway completion groups and the qualification for each group.

Table 4

Pathway Completion Groups

Group	Percent Completion Range	Description
Group 1	25%-49%	Students would have completed 25%-49% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. These students would be enrolled in courses beyond Advanced Algebra II if enrolled in Algebra I as a seventh or eighth grader. If enrolled in Algebra I as ninth grader, these students would most likely not have been enrolled in enough math coursework for graduation.
Group 2	50%-74%	Students would have completed 50%-74% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group enrolled in Algebra I in seventh grade may complete one AP Calculus course. Students enrolled in Algebra I in eighth grade may have completed Precalculus and students who were enrolled in Algebra I as ninth grader would may have completed their third math credit of Algebra II.
Group 3	75%-99%	Students would have completed 75%-99% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group who were enrolled in Algebra I as a seventh grader would have been enrolled in at least one AP Calculus course as well as another AP course. Students enrolled in in Algebra I in eighth grade would be enrolled in a Calculus or Statistics Course. Ninth grade Algebra I students would have been enrolled in a precalculus class or a combination of two semester courses that include Discrete Math, Statistics, and College Algebra.
Group 4	100%-124%	Students would have completed 100%-124% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Group 4 is very similar to Group 3 in that students are completed the expected pathways and may take an extra or more advanced math course regardless of enrollment of Algebra I occurred.
Group 5	125%-149%	Students would have completed 125%-149% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group would most likely need to double up on advanced math courses for at least one year.
Group 6	150%-174%	Students would have completed 150%-174% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group would most likely need to double up on math courses for at least two years.
Group7	175%-199%	Students would have completed 150%-174% of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group would most likely need to double up on advanced math courses for at least two years. Students who enrolled in seventh grade Algebra I would not be in this Group due to limited course availability.

Group	Percent Completion Range	Description
Group 8	200% or more	Students would have completed 200% or more of the expected level of coursework dependent on course ratings by the grade level enrolled in Algebra I. Students in this group would most likely need to double up on advanced math courses for at least three years. Students who enrolled in seventh grade Algebra I would not be in this Group due to limited course availability.

Table 5 shows the distribution of the extent to which students completed the expected mathematics pathway based on when a student was enrolled in Algebra I. Course pathway groups 3 and 4 included students who completed approximately 100% of the expected pathway from the grade they were enrolled in Algebra I. Of all the students enrolled in seventh grade Algebra I (n=237), 71.30% or 170 students fell into groups 3 and 4. Students enrolled in eighth grade Algebra I (n=1634) had the highest percentage of students completing the expected pathway with 74.92% or 1224 students in groups 3 and 4 and 6.55% or 107 students in groups 5 and 6. Finally, the students enrolled in Algebra I in ninth grade (n=2841) had 69.87% or 1985 students falling into groups 3 and 4. While ninth grade Algebra I had a lower percentage in the Group 3 and 4, this group was the only group to have students in groups 7 and 8. Over the six years this study covered, nine students who were enrolled in ninth grade Algebra I were able to complete over 175% of the expected mathematics course pathway.

Table 5

Grade Level Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Grade Level	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Seventh Grade (*n*=237)	2.53	24.05	40.08	31.22	2.11	.00	.00	.00
Eighth Grade (*n* = 1634)	2.02	16.52	50.31	24.60	6.06	.49	.00	.00
Ninth Grade (*n* = 2841)	6.83	18.27	56.85	13.02	4.00	.74	.21	.11

Note. % = percent of total enrolled in Algebra I at grade level. Groups based on completion of expected pathways (See Table 1).

In looking at demographic patterns and coursework, Table 6 shows patterns related to course pathway completion group and gender. The group with the highest percentage of students regardless of gender was Group 3. Overall, males completed less of the expected pathways compared to females. Males had 12.57 fewer percentage points in Groups 3 and 4 combined. In the lower Groups, 1 and 2, males had 11.43 more percentage points than females. These two groups were comprised of students who completed less than three-fourths of the expected pathways.

Table 6

Gender Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Gender	%	%	%	%	%	%	%	%
Male (*n*=2377)	6.77	21.79	47.20	18.26	5.00	.72	.17	.08
Female (*n* = 2335)	3.08	14.05	60.39	17.64	4.20	.51	.09	.04

Note. % = percent of total enrolled in Algebra I. Groups based on completion of expected pathways (See Table 1).

Table 7 represents the coursework pathway completion group patterns demonstrated by the racial groups in the district during the six-year period of the study of students enrolled in Algebra I in seventh, eighth, or ninth grade. Overall pattern results revealed each racial group having approximately one-fourth of students in Groups 1 and 2 and three-fourths of students in Groups 3 and 4. The groups that did not necessarily fall into this pattern were Asian (*n*=99) and Black (*n*=345) students. There were only 13.10% or 13 of Asian students in Group 2 and almost 80% or 80 students in Groups 3 and 4. Group 1 did not have any Asian students. Asian students also had the highest percentage in Groups 5 through 8 (7% or 7 students) in which students completed more than the expected course pathways. The racial group with the highest percentage of students not completing the expected pathway were Black students with 31.80% of students in Groups 1 and 2 and only 63.20% in Group 3 and 4. However, there were 5% of Black students who did complete more than the expected pathways and were in Groups 5, 6, and 7. This is one of the higher percentages of the racial groups where students were completing more than the expected pathways. These groups are compared to the group of White students with a much larger *n*-value of 4180.

Table 7

Racial Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Race	%	%	%	%	%	%	%	%
Asian (*n*=99)	.00	13.10	55.60	24.20	3.00	4.00	.00	.00
Black (*n* = 345)	13.00	18.80	46.40	16.80	4.10	.60	.30	.00
Hispanic (*n*=66)	10.60	16.70	57.60	13.60	1.50	.00	.00	.00
Indian (*n*=17)	11.80	17.60	64.70	5.90	.00	.00	.00	.00
Pacific Islander (*n*=5)	20.00	.00	80.00	.00	.00	.00	.00	.00
White (*n*=4180)	4.30	18.00	54.20	18.00	4.80	.60	.10	.10

Note. % = percent of total enrolled in Algebra I. Groups based on completion of expected pathways (See Table 1).

Continuing to look at demographic patterns of course pathway groups, Table 8 shows results of course pathway group and socio-economic status patterns. Students classified as low socio-economic status by qualifying for the free and reduced lunch program. Only 58.4% or 348 students in the free and reduced lunch program (*n*=595) fell into Groups 3 and 4 compared to 73.6% or 3030 students in the standard lunch program (*n*=4117) were in Groups 3 and 4. This was a difference of 15.2 percentage points, keeping in mind the large difference in the number of students in each lunch program. Similarly, the percent of free and reduced lunch students who completed less than three-fourths of the expected pathway and fell into Groups 1 and 2 was 16.4 percentage points higher than students in the standard lunch program. There were 4.4% or 26 free and reduced lunch program students who were able to complete more than the expected pathway and were in Groups 5 and 6 compared to 5.6% or 230 standard lunch program students in groups 5 through 8.

Table 8

Socio-economic Status Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
SES	%	%	%	%	%	%	%	%
Free/Reduced (*n*=595)	11.30	25.90	45.00	13.40	3.40	1.00	.00	.00
Standard (*n* = 4117)	4.00	16.80	55.00	18.60	4.80	.60	.10	.10

Note. % = percent of total enrolled in Algebra I. Groups based on completion of expected pathways (See Table 1).

Another demographic group of interest explored related to pattens and course pathway group was special education students. In Table 9 students enrolled in a special education program (*n*=306), as indicated with having an Individualized Education Plan (IEP), had a large percentage (60.5%) or 185 students that fell into Groups 1 and 2 with only 37.9% or 116 students in Groups 3 and 4. This percentage of students in Groups 1 and 2 is 40.2 percentage points higher than non-special education students. Regular education students (*n*=4406) had 74% or 3260 students in Groups 3 and 4 or 36.1 points higher than special education students. There were five special education students who fell into the groups that exceed the expected pathways (1.60%).

Table 9

Special Education Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Special Education	%	%	%	%	%	%	%	%
IEP (*n*=306)	28.10	32.40	32.70	5.20	1.30	.00	.30	.00
No IEP (*n* = 4406)	3.30	17.00	55.20	18.80	4.80	.70	.10	.10

Note. % = percent of total enrolled in Algebra I. IEP = Individualized Education Plan, indicates a student's participation in special education. Groups based on completion of expected pathways (See Table 1)

Table 10 displays the course pathway completion group patterns for gifted and non-gifted students. Gifted students (*n*=83) had a low percentage (10.8%) or 9 students in Group 2 and no students fell in Group 1 of pathway completion compared to 23.1% or 1069 non-gifted students in Groups 1 and 2. 83.2% or 69 gifted students were in Groups 3 and 4 with 6% or five students exceeding expected completion in Group 5. The percent of gifted students Groups 3 and 4 was 11.7 percentage points higher than non-gifted students.

Table 10

Gifted Pathway Group Frequency

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Gifted	%	%	%	%	%	%	%	%
Gifted (*n*=83)	.00	10.80	43.40	39.80	6.00	.00	.00	.00
Non Gifted (*n* = 4629)	5.00	18.10	53.90	17.60	4.60	.60	.10	.10

Note. % = percent of total enrolled in Algebra I. Groups based on completion of expected pathways (See Table 1)

One of the goals of students enrolling in an accelerated pathway and taking Algebra I early was to be able to enroll in and successfully complete AP Calculus by graduation. The enrollment trend of AP Calculus AB is indicated in Table 11 showing the mean and standard deviation of percentage of students in each grade level group who enrolled in AP Calculus AB. Seventh grade Algebra I grade level groups have the highest mean percentage of students who enrolled in AP Calculus AB by graduation. The lowest mean percentage of enrollment in AP Calculus AB occurred with the ninth grade Algebra I grade level group.

Table 11

Enrollment in AP Calculus AB by Algebra I Grade Level Groups

	Enrollment in AP Calculus AB	
Algebra I Grade Level Groups	*M*	*SD*
Seventh Grade (*n*=237)	65.73	6.00
Eighth Grade (*n*=1634)	23.00	9.59
Ninth Grade(*n*=2841)	.58	.51

Note. *M* = mean. *SD* = standard deviation. Mean scores indicate the average yearly percentage enrolled in AP Calculus AB over the six-year period.

Table 12 breaks down the enrollment in AP Calculus AB into the different demographic groups to further examine patterns. In all Algebra I grade level groups, males (*n*=2377) enrolled in AP Calculus AB at a higher rate than females (*n*=2335). Asian students (*n*=99) had a high rate of enrollment into AP Calculus AB in all grade level groups. The small group of Black students enrolled in seventh grade Algebra I (*n*=4) all continued on to enroll in AP Calculus AB by graduation. However, Black students enrolled in eighth or ninth grade Algebra I (*n*=341) had the lowest rate of enrolling in AP Calculus AB compared to other racial groups in the same grade level groups. There were not any Hispanic students from the seventh (*n*=0) or ninth grade (*n*=51) Algebra I grade level groups that enrolled in AP Calculus AB. Students eligible for the free and reduced lunch program (*n*=595) enrolled in AP Calculus AB at a lower rate than students in the standard lunch program (*n*=4117) in both seventh and eighth grade Algebra I grade level groups. In the ninth grade Algebra I grade level group, student in the free and reduced lunch program had a higher enrollment rate than students in the standard lunch program. Students in the special education program (*n*=306) only enrolled in AP Calculus AB from the eighth grade Algebra I grade level group. Gifted students (*n*=83) enrolled in in AP Calculus at higher rate than non-gifted students (*n*=4629) at the seventh and eighth grade Algebra I grade levels.

Table 12

Enrollment in AP Calculus AB by Algebra I Grade Level Groups and Demographics

	Enrollment in AP Calculus AB					
	Seventh Grade Algebra I		Eighth Grade Algebra I		Ninth Grade Algebra I	
Demographic Groups	*n*	%	*n*	%	*n*	%
Male	131	64.89	782	27.88	1464	.75
Female	106	59.43	852	19.13	1377	.29
Asian	11	81.82	50	38.00	38	2.86
Black	4	100.00	72	22.73	269	.48
Hispanic	0	*	15	38.46	51	*
White	221	62.50	1494	23.46	2465	.64
Free/Reduced	11	45.46	116	11.21	468	.64
Standard	226	63.27	1518	23.58	2373	.51
IEP	1	*	15	6.67	290	*
No IEP	235	62.71	1619	23.47	2551	.59
Gifted	33	87.88	39	48.72	11	*
Non Gifted	204	58.33	1595	22.70	2830	.53

Note. %=Percentage of group enrolled in AP Calculus AB. *=Students in groups did not take AP Calculus AB. IEP = Individualized Education Plan, indicates a student's participation in special education

Table 13 breaks down the enrollment in AP Calculus AB into the graduation years and is visualized in in Figure 2. The highest percentage of AP Calculus AB enrollment for each Algebra I grade level group occurred with the 2015 graduation class. From there, the enrollment percentage pattern for seventh and eighth grade Algebra I grade level groups in AP Calculus AB declined. The lowest enrollment in AP Calculus AB for the seventh grade Algebra I grade level group was the 2018 graduating class (*n*=22) with 59.1% enrollment or 13 students. Eighth grade Algebra I grade level group's lowest enrollment in AP Calculus AB occurred with the graduating class of 2020 (*n*=209) with 9.1% or 19 students. The enrollment percentage pattern for the ninth grade Algebra I grade level group stayed fairly constant.

Table 13

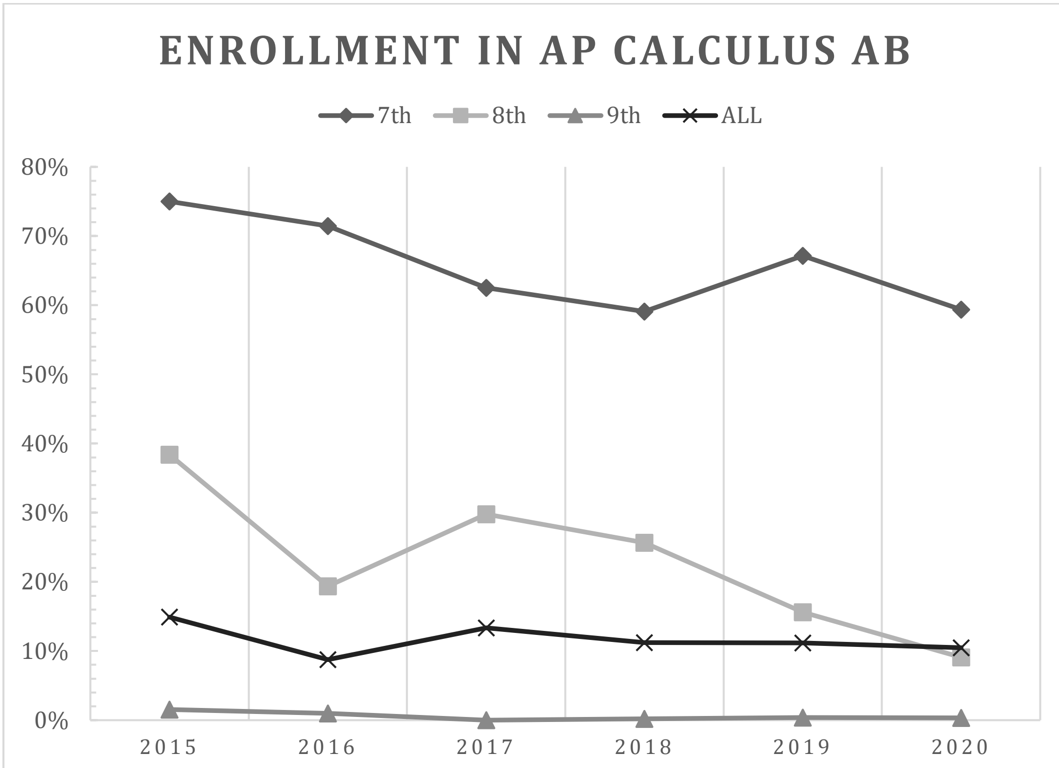
Total Enrollment of Algebra I students that Completed AP Calculus by Graduation Year

Grade Level Group	2015		2016		2017		2018		2019		2020	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	n	%
Seventh Grade	4	75.00	7	71.43	8	62.50	22	59.09	73	67.12	123	59.35
Eighth Grade	211	38.39	258	19.38	339	29.79	335	25.67	282	15.60	209	9.09
Ninth Grade	389	1.54	409	.98	447	.00	534	.19	496	.40	566	.35

Note. % = percent of total enrolled in Algebra I that completed AP Calculus AB.

Figure 2

Enrollment in AP Calculus AB by Graduation Year



The average performance on the mathematics portion of ACT and the Algebra I End of Course (EOC) exam for each pathway group is displayed in Table 14 and Figures 3 and 4. The data as the percentage of pathway completion increased, the ACT mathematics scores and EOC levels also gradually increased overall. The range for ACT mathematics score is 1 to 36 (ACT, 2021). The range for EOC is 1 to 4. The ACT mathematics scores increase by 11.98 points from Group 1 who completed 24%-49% of their expected course pathway to Group 8 who completed over 200% of their expected course pathway. The district average ACT mathematics score was 21.58. This score fell within Group 3. Group 3 (*n*=2334) completed 75%-99% of their expected course pathway. EOC levels increased by 1.39 levels from Group 1 to Group 8. EOC proficiency is indicated by a “3” which also first fell within Group 3.

Table 14

Pathway Groups Performance on ACT and EOC

	ACT Mathematics Score			EOC Level*		
Group	*n*	*M*	*SD*	*n*	*M*	*SD*
Group 1	122	16.35	3.15	202	2.28	1.29
Group 2	633	20.48	4.55	790	2.82	.86
Group 3	2334	21.98	4.40	2420	3.09	.78
Group 4	816	25.07	5.15	822	3.46	.69
Group 5	210	25.51	5.08	202	3.47	.70
Group 6	28	25.89	3.92	28	3.39	.69
Group 7	6	25.33	2.94	6	3.33	.52
Group 8	3	28.33	1.16	3	3.67	.58

Note. *EOC = End of Course Exam*

* EOC Levels are represented as follows: 1 = Below Basic, 2 = Basic, 3 = Proficient, 4 = Advanced

Figure 3

Pathway Groups ACT Mathematics Performance

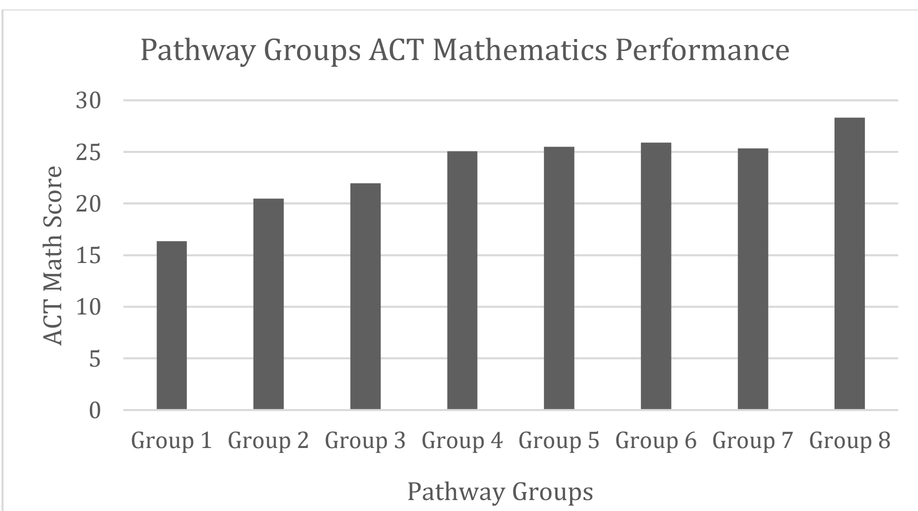
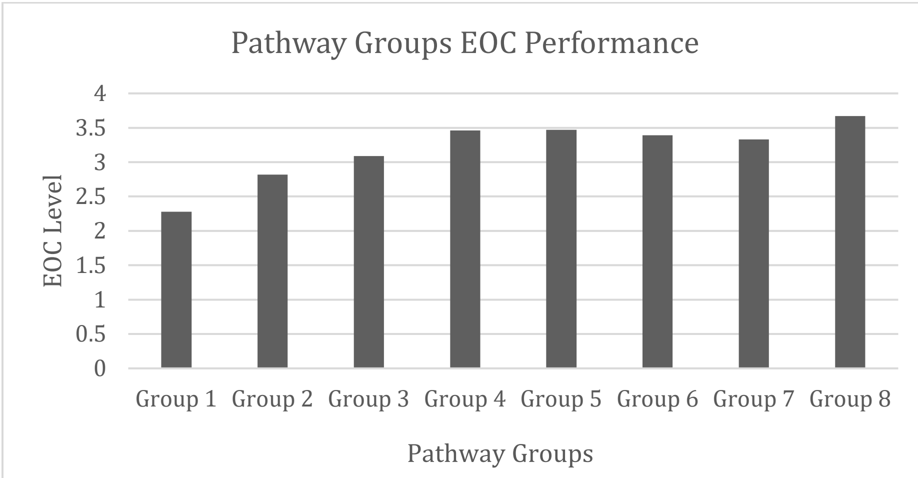


Figure 4

Pathway Groups EOC Performance



Given the emphasis on students' achievement, further exploration of patterns was conducted on completed expected course pathway and EOC and ACT performance using ANOVA. In reviewing the results of the ANOVA in Table 15 for the ACT performance between course pathway groups, there was a statistically significant difference between pathway groups, $F(7,4144) = 105.91$, $p = .000$. The EOC performance between course pathway groups results from the ANOVA also showed a statistically significant difference between pathway groups $F(7,4465) = 74.71$, $p = .000$.

Table 15

Analysis of Variance in ACT and EOC performance between Course Pathway Groups

		SS	*df*	*MS*	*F*	*p*
ACT Math Score	Between Groups	15537.46	7	2219.64	105.91	.000
	Within Groups	86852.49	4144	20.96		
	Total	102389.95	4151			
EOC Level	Between Groups	337.72	7	48.25	74.71	.000
	Within Groups	2883.22	4465	.65		
	Total	3220.94	4472			

The data in this section showed patterns are evident regarding academics, demographics, and the coursework taken during by students in the graduating classes from 2015-2020 and who were enrolled in Algebra I in seventh, eighth, or ninth grade. Therefore, the null hypothesis would be rejected.

Increase in 7th Grade Algebra I Enrollment

H_0 2: There are no significant student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES) as the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020.

In looking at students who were enrolled in seventh grade Algebra I and graduated between the years of 2015 and 2020, Table 16 shows the mean and standard deviation of scores for ACT Mathematics, EOC Levels, and Expected Course Pathway for students over the years. As the enrollment in seventh grade Algebra I increased by 115 students, the average ACT mathematics scored decreased by 4.65 points. This is also demonstrated in Figure 5.

EOC levels and percent completion of expected course pathways stayed relatively consistent as indicated by result of the ANOVA in Table 17 that did not show a statistically significant difference the years for EOC levels, $F(5,229) = .79$, $p = .558$ and percent completion of expected course pathways, $F(5,231) = .63$, $p = .676$. There was a statistically significant difference between the years for ACT Mathematics Score, $F(5,226) = 3.30$, $p = .007$, indicating the downward trend is significant.

Table 16

Seventh Grade Algebra I Academic Performance for Graduation Year Groups

Graduation Year	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
2015	4	33.75	4.50	4	3.75	.50	4	.96	.17
2016	7	31.43	5.03	7	4.00	.00	7	.87	.18
2017	8	32.25	3.01	8	4.00	.00	8	.85	.16
2018	22	29.18	3.84	22	3.86	.35	22	.88	.17
2019	72	30.04	3.33	71	3.90	.30	73	.93	.18
2020	119	29.10	3.33	123	3.81	.52	123	.89	.20

Figure 5

Seventh Grade Algebra I Math Performance by Graduation Year

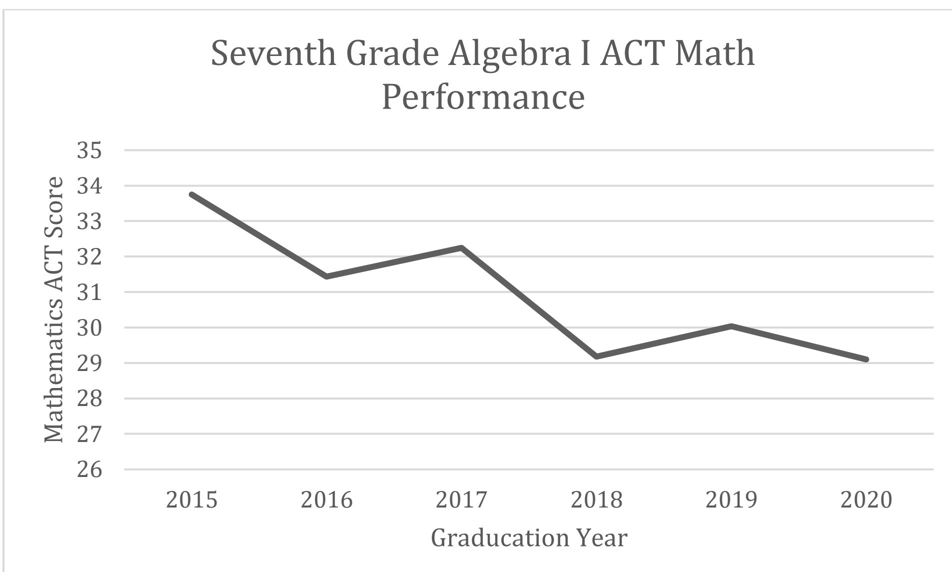


Table 17

Analysis of Variance in ACT and EOC performance and Completion of Expected Pathway between Graduation Years

		SS	*df*	*MS*	*F*	*p*
ACT Math Score	Between Groups	195.20	5	30.04	3.30	.007
	Within Groups	2676.90	226	11.85		
	Total	2872.10	231			
EOC Level	Between Groups	.73	5	.15	.79	.558
	Within Groups	42.35	229	.19		
	Total	43.08	234			
Pathway Completion	Between Groups	.11	5	.02	.63	.676
	Within Groups	8.28	231	.04		
	Total	8.39	236			

Demographic patterns for seventh grade Algebra I are shown in tables 18 through 25. Gender is listed in Table 18. Overall, in graduation years 2015 through 2020, the seventh grade Algebra I grade level group (*n*=237) was 53.3% male and 44.7% female. The average percentage for gender groups for the district during this time period was males, 51.8% and females, 48.2%. The year with the biggest discrepancy was the 2017 graduating class with 87.5% male and 12.5% female, keeping in mind this was a small population of 8 students. Each graduating class, with the exception of 2016, males outnumbered females in the seventh grade Algebra I grade level group by an average of 20.4 percentage points keeping in mind several small populations.

Table 18

Seventh Grade Algebra I Gender by Graduation Year

Graduation	Male		Female	
Year	*n*	%	*n*	%
All Years	131	55.27	106	44.73
2015 (*n* = 4)	3	75.00	1	25.00
2016 (*n* = 7)	3	42.86	4	57.14
2017 (*n* = 8)	7	87.50	1	12.50
2018 (*n* = 22)	13	59.09	9	40.91
2019 (*n* = 73)	43	58.90	30	41.10
2020 (*n* = 123)	62	50.41	61	49.59

Note. % = percent of total enrolled in seventh grade Algebra I for graduation year.

Looking at these same years and gender, Table 19 shows performance by gender with each graduation year. Each year, with the exception of 2015, males had a higher average ACT mathematics score than females with both groups trending downward over the six-year period. There was not much of a difference between genders with EOC levels. There were 2 years males averaged higher than females, 2 years males averaged lower, and 2 years where they averaged the same. With completion of expected course pathway, males completed more of the pathway than females in four of the six years. In the first graduation class, the one female was able to complete more than the expected course pathway.

Table 19

Seventh Grade Algebra I Performance by Graduation Year and Gender

Graduation Year	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
2015									
Male	3	33.00	5.20	3	3.67	.58	3	.89	.15
Female	1	36.00	-	1	4.00	-	1	1.14	-
2016									
Male	3	32.33	5.51	3	4.00	.00	3	.88	.23
Female	4	30.75	5.38	4	4.00	.00	4	.87	.18
2017									
Male	7	32.29	3.25	7	4.00	.00	7	.86	.17
Female	1	32.00	-	1	4.00	-	1	.77	-
2018									
Male	13	30.00	4.16	13	3.85	.38	13	.90	.20
Female	9	28.00	3.16	9	3.89	.33	9	.87	.13
2019									
Male	42	30.93	2.92	43	3.98	.15	43	.95	.17
Female	30	28.80	3.51	28	3.79	.42	30	.89	.20
2020									
Male	59	29.46	3.22	62	3.84	.52	62	.88	.21
Female	60	28.75	3.42	61	3.79	.52	61	.90	.18

In Table 20, the distribution of race in the seventh grade Algebra I grade level group is examined over the graduation years along with looking at all the graduation years combined. These patterns can be compared with the district averages over the same time period. The following are the average percentages of the various racial groups for the district during the years of 2015 to 2020: Asian, 1.9%; Black, 6.6%; Hispanic, 4.5%; Indian, 0.2%; Multiracial, 3.6%; Pacific Islander, 0.1% and White, 83.2%. The first three graduation years (2015-2017) of the seventh grade Algebra I grade level group (*n*=19) were 100% White. During the graduation years of 2018 to 2020, the seventh grade

Algebra I grade level group (*n*=218)) included Asian, Black and Indian along with White students. The Asian enrollment percentages were higher than the district average for 2018 (*n*=1) by 2.6 points, 2019 (*n*=5) by 5 points, and 2020 (*n*=5) by 2.2 points with no enrollment in 2015, 2016, and 2017 graduating classes. The Black enrollment percentage was higher than the district average for 2018 (*n*=2) by 2.5 points and lower in 2019 (*n*=2) by 3.9 points with no enrollment in 2015, 2016, 2017, and 2020 graduating classes. There were no Hispanic or Pacific Islander students enrolled in seventh grade Algebra I in any graduating class. Indian students were represented in the 2020 graduating class (*n*=1) with an enrollment in seventh grade Algebra 0.6 points higher than the district average.

Table 20

Seventh Grade Algebra I Race by Graduation Year

Graduation Year	Asian		Black		Indian		White	
	n	%	*n*	%	*n*	%	*n*	%
All Years	11	4.6	4	1.7	1	0.4	221	93.2
2015 (*n* = 4)	0	.00	0	.00	0	.00	4	100.00
2016 (*n* = 7)	0	.00	0	.00	0	.00	7	100.00
2017 (*n* = 8)	0	.00	0	.00	0	.00	8	100.00
2018 (*n* = 22)	1	4.50	2	9.10	0	.00	19	86.40
2019 (*n* = 73)	5	6.80	2	2.70	0	.00	66	90.40
2020 (*n* = 123)	5	4.10	0	.00	1	.80	117	95.10

Note. % = percent of total enrolled in seventh grade Algebra I for graduation year.

In Table 21, academic performance and expected course pathway completion is examined by graduation year and racial groups. For the first three graduation years, 2015-2017, the only racial group enrolled in Algebra I (*n*=19) in seventh grade was White. The Asian student (*n*=1) of the 2018 graduating class had the highest average ACT Mathematics score with a 35 and matched the Black students (*n*=2) with the highest EOC level. The expected pathway course completion was highest for the Asian student as well. With the 2018 graduation class, Black students had a higher average ACT Mathematics score than White students (*n*=66) in same graduating year by 3.97 points as well as a higher EOC level average. However, the Black student average for expected course pathway completion was the lowest among 2018 graduates.

Students in the 2019 graduating class included Asian (*n*=5), Black (*n*=2), and White (*n*=123). Again, the Asian ACT Mathematics score average was the highest of the racial groups. Asian students also had the highest EOC level and expected course pathway completion averages. The 2019 graduating glass is the last class that saw Black students enrolled in Algebra I in seventh grade. This group had the lowest ACT Mathematics score and expected course pathway completion averages. The average EOC level for Black students matched that of Asian students in the 2019 graduating class.

The 2020 graduating class saw Asian (*n*=5), Indian (*n*=1), and White (*n*=117) students who enrolled in Algebra I in seventh grade. Asian students outperformed in all three areas, ACT Mathematics, EOC level, and expected course pathway completion. There was only one Indian student in the 2020 grading class. The ACT Mathematics score, EOC level and expected course pathway completion for this student was lower than the Asian and White student groups.

Table 21

Seventh Grade Algebra I Performance by Graduation Year and Racial Groups

Graduation Year	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
2015									
White	4	33.75	4.50	4	3.75	.50	4	.96	.17
2016									
White	7	31.43	5.03	7	4.00	.00	7	.87	.19
2017									
White	8	32.25	3.01	8	4.00	.00	8	.85	.16
2018									
Asian	1	35.00	-	1	4.00	-	1	1.04	-
Black	2	32.50	2.12	2	4.00	.00	2	.85	.18
White	19	28.53	3.66	19	3.84	.38	19	.88	.18
2019									
Asian	5	31.60	4.16	5	4.00	.00	5	.94	.12
Black	2	29.00	.00	2	4.00	.00	2	.87	.19
White	65	29.95	3.31	64	3.89	.32	66	.93	.19
2020									
Asian	5	30.00	2.24	5	3.80	.45	5	.95	.02
Indian	1	25.00	-	1	4.00	-	1	.72	-
White	113	29.10	3.33	117	3.81	.52	117	.89	.20

Another pattern of the seventh grade Algebra I grade level group was the lunch status by graduation year as shown in Table 22. The district average during the same time period from 2015-2020 was 18.9%. The overall average for the seventh grade Algebra I grade level group during the same time was 4.6% or 11 students. There are two graduation years, 2016 and 2017, in which the seventh grade Algebra I grade level group saw no free/reduced students. In the other year, the percent of students stayed fairly consistent.

Table 22

Seventh Grade Algebra I Lunch Status by Graduation Year

Graduation Year	Free/Reduced		Standard	
	n	%	*n*	%
All Years	11	4.6	226	95.4
2015 (*n* = 4)	1	25.0	3	75.0
2016 (*n* = 7)	0	0.0	7	100.0
2017 (*n* = 8)	0	0.0	8	100.0
2018 (*n* = 22)	1	4.5	21	95.5
2019 (*n* = 73)	4	5.5	69	94.5
2020 (*n* = 123)	5	4.1	118	95.9

Note. % = percent of total enrolled in seventh grade Algebra I for graduation year.

Table 23 shows how students in the different socio-economic groups performed separated by the different graduation years. When looking at ACT Mathematics, students who were part of the free/reduced lunch program (*n*=9) scored higher than standard students (*n*=223) with the exception of the 2020 graduating class. In 2016 and 2017 graduation years, there were not any students who had been enrolled in Algebra I in seventh grade who were also part of the free/reduced lunch program. For EOC levels, free/reduced lunch program students (*n*=11) had a higher average two out of the four years in which the group was represented. Finally, students qualifying for free and reduced lunch program (*n*=11) had a higher expected course pathway completion for one year, equal to for one year, and lower for two years when compared to students in the standard lunch program (*n*=226).

Table 23

Seventh Grade Algebra I Performance by Graduation Year and Lunch Status

Graduation Year	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
2015									
Reduced	1	36.00	-	1	4.00	-	1	1.14	-
Standard	3	33.00	5.20	3	3.67	.58	3	.89	.15
2016									
Standard	7	31.43	5.03	7	4.00	.00	7	.87	.18
2017									
Standard	8	32.25	3.01	8	4.00	.00	8	.85	.16
2018									
Free	1	34.00	-	1	4.00	-	1	.98	-
Standard	21	28.95	3.78	21	3.86	.36	21	.88	.18
2019									
Free	3	30.33	3.22	4	3.75	.50	4	.80	.27
Standard	69	30.03	3.35	67	3.91	.29	69	.94	.18
2020									
Free	2	29.00	2.83	3	4.00	.00	3	.88	.12
Reduced	2	27.00	2.83	2	2.50	2.12	2	.91	.13
Standard	115	29.14	3.35	118	3.83	0.46	118	.89	.20

The programs and services examined in the study included special education and gifted. Table 24 represents the percent of students receiving these services in the seventh grade Algebra I grade level group. The district average during the same time from 2015-

2020 of students with an IEP was 12.90% and 4.90% for gifted. The overall average for the seventh grade Algebra I grade level group (*n*=237) for IEP was 0.4% or 1 student and 13.9% or 33 students for gifted. There was only one graduating class in which a special education student with an IEP (Individualized Education Plan) was enrolled in seventh grade Algebra I. There is a large difference between the seventh grade Algebra I enrollment and the district with both IEP/Special Education and Gifted programs.

Table 24

Seventh Grade Algebra I Programs and Services by Graduation Year

Graduation Year	IEP		Gifted	
	n	%	*n*	%
All Years	1	0.4	33	13.9
2015 (*n* = 4)	0	0.0	0	0.0
2016 (*n* = 7)	0	0.0	0	0.0
2017 (*n* = 8)	0	0.0	0	0.0
2018 (*n* = 22)	0	0.0	6	23.7
2019 (*n* = 72)	0	0.0	23	31.5
2020 (*n* = 119)	1	0.8	4	3.3

Note. % = percent of total enrolled in seventh grade Algebra I for graduation year. IEP = Individualized Education Plan, indicates a student's participation in special education.

The enrollment in seventh grade Algebra I did not see gifted students during the 2015-2017 graduation years and only saw one special education student in the 2020 graduation year. Table 25 shows performance averages for the graduation years that did have enrollment in these programs. Gifted students in the 2019 graduation class showed the highest ACT Mathematics performance and expected course pathway completion. In all years, gifted students outperformed non-gifted students in ACT Mathematics, EOC level and expected course pathway completion. There was one special education student enrolled in Algebra I in seventh grade and was a part of the 2020 graduating class. This student outperformed regular education students in ACT Mathematics and EOC level, however only had a .68 expected course pathway completion.

Table 25

Seventh Grade Algebra I Performance by Graduation Year and Programs and Services

Graduation Year	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
2018									
Gifted	6	30.83	3.60	6	4.00	.00	6	.95	.00
Non Gifted	16	28.56	3.85	16	3.81	.40	16	.86	.20
2019									
Gifted	23	32.00	2.70	23	4.00	.00	23	1.00	.16
Non Gifted	49	29.12	3.21	48	3.85	.36	50	.89	.18
2020									
Gifted	4	31.50	3.70	4	4.00	.00	4	.92	.19
Non Gifted	115	29.02	3.30	119	3.81	.53	119	.89	.20
IEP	1	30.00	-	1	4.00	-	1	.68	-
No IEP	118	29.09	3.41	122	3.81	.52	122	.89	.20

Note: IEP = Individualized Education Plan, indicates a student's participation in special education

As the enrollment in seventh grade Algebra I increased there are patterns that are evident within academic performance as well as demographic enrollment and performance, therefore the null hypothesis would be rejected.

Seventh Grade Algebra I compared to Eighth and Ninth Grade Algebra I

H_0 3: There are no student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e., gender, ethnicity, SES) when comparing between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years of 2015 and 2020.

Comparing seventh grade Algebra I grade level groups to eighth and ninth grade Algebra I grade level groups highlights any differences, if any, both academically and demographically that exist between the groups. If differences exist they may lead to the questions of performance gaps and equity in access to higher mathematics for certain groups of students.

Table 26 shows the mean and standard deviation of the ACT mathematics scores, EOC

levels, and percent completion of expected course pathways for the seventh, eighth, and ninth grade Algebra I grade level groups individually. Seventh grade Algebra I grade level group that consisted of 237 students (*M* = 29.66, *SD* = 3.53), had the highest mean ACT mathematics score by 4.07 points over eighth grade Algebra I grade level group (*M* = 25.59, *SD* = 3.70) with 1634 students, and 10.14 points of ninth grade Algebra I grade level group (*M* = 19.52 *SD* = 3.59) consisting of 2841 students.

Table 26

Grade Level Performance

Algebra I Grade Level	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Seventh Grade	235	29.66	3.53	232	3.86	.43	237	.90	.19
Eighth Grade	1590	25.59	3.70	1594	3.63	.52	1634	.93	.19
Ninth Grade	2330	19.52	3.59	2644	2.70	.81	2841	.89	.24

Similarly, with EOC levels, the seventh grade Algebra I grade level group (*n*=237, *M*=3.86, *SD*=.43) had higher levels than the eighth grade Algebra I grade level group (*n*=237, *M*=3.63, *SD*=.52) by .23 points and higher than ninth grade Algebra I grade level group (*n*=2841, *M*=2.70, *SD*=.81) by 1.16 points.

When examining and comparing the average percent completion of expected course pathway, seventh grade Algebra I grade level group (*M* = .90, *SD* = .19) falls below eighth grade Algebra I grade level group (*M* = .93, *SD* = .19) by .03 points and is higher than ninth grade Algebra I grad level group (*M* = .89, *SD* = .24) by .01 points.

The ANOVA results in Table 27 reflect ACT mathematics scores, EOC levels, and

percent completion of expected pathways between grade level groups. In the ANOVA comparing ACT mathematics scores, a significant difference was found between the grade level groups, $F(2,4149) = 1815.16$, $p = .000$. Likewise, when comparing EOC levels, there was a significant difference between the grade level groups, $F(2,4470) = 1013.74$, $p = .000$. The percent completion of expected course pathway comparison between grade level groups showed a significant difference, $F(2,4709) = 16.97$, $p = .000$.

Table 27

Analysis of Variance in ACT, EOC, and Completion Percentage between Grade Levels

		SS	*df*	*MS*	*F*	*p*
ACT Mathematics Score	Between Groups	47781.55	2	23890.77	1815.16	.000
	Within Groups	54608.41	4149	13.16		
	Total	102389.95	4151			
EOC Level	Between Groups	1005.07	2	502.53	1013.74	.000
	Within Groups	2215.87	4470	.50		
	Total	3220.94	4472			
Percent Completion of Expected Pathway	Between Groups	1.653	2	.83	16.97	.000
	Within Groups	229.37	4709	.05		
	Total	231.02	4711			

In addition to academic performance patterns, demographic patterns were examined. Table 28 displays the enrollment patterns of Algebra I in each grade level group by graduation year and gender for eighth and ninth grade Algebra I grade level groups most closely reflected the district averages of males, 51.8% and females, 48.2%. The seventh grade Algebra I grade level group's gender percentage was 7.1 points different from the district percentage with males being higher and females being lower.

Table 28

Grade Level Algebra I Gender

	Male	Female
Grade Level Group	%	%
Seventh Grade (*n*=237)	55.3	44.7
Eighth Grade (*n*=1634)	47.9	52.1
Ninth Grade (*n*=2841)	51.5	48.5
District (*n*=93080)	48.2	51.8

Note. % = percent of total enrolled in Algebra I at grade level.

Table 29 looks at grade level performance broken down by gender. As mentioned in the review of the overall data for grade level performance, seventh grade Algebra grade level group outperforms eighth and ninth grade Algebra grade level groups. When examining gender patterns, males outperform females on ACT mathematics and EOC levels at all grade levels. On the ACT mathematics, seventh grade Algebra I males scored an average 1.43 points higher than their female counterparts, .08 points higher on EOC levels, and .02 percentage points higher on expected course pathway completion. Eighth grade Algebra I males scored an average of 1.10 higher on ACT mathematics and were equal with females on EOC levels. The smallest gap on ACT mathematics and EOC levels occurred with ninth grade Algebra I students. Males averaged .55 points higher than females on ACT mathematics and .02 points higher on EOC levels. Female students in eighth and ninth grade Algebra I grade level groups outperformed male counterparts on expected course pathway completion by .01 in the eighth-grade group and .05 in the ninth-grade group.

Table 29

Grade Level Performance by Gender

Algebra I Grade Level	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Seventh Grade									
Male	127	30.31	3.40	131	3.89	.40	131	.91	.19
Female	105	28.88	3.53	104	3.81	.46	106	.89	.18
Eighth Grade									
Male	751	26.17	3.9	766	3.63	.52	782	.93	.21
Female	839	25.07	3.44	828	3.63	.53	852	.94	.18
Ninth Grade									
Male	1133	19.80	3.79	1356	2.71	.85	1464	.87	.26
Female	1197	19.25	3.36	1288	2.69	.77	1377	.92	.21

The next demographic to be compared between the grade level groups for Algebra I was race by graduation year. Table 30 shows average percentage of racial enrollment for each Algebra I grade level group along with the district enrollments during the time from 2015 to 2020. Seventh grade Algebra I grade level group had a higher percentage of Asian (*n*=11), Indian (*n*=1), and White (*n*=221) enrollments than eighth grade Algebra I (Asian, *n*=50; Indian, *n*=2; White, *n*=1494) and the district (Asian, *n*=1816; Indian, *n*=208; White, *n*=80316). Seventh grade Algebra I had a higher percentage of Asian and White enrollments than ninth grade (Asian, *n*=38; White, *n*=2465). Seventh grade Algebra I had a lower percentage of Black (*n*=4), Hispanic (*n*=0), and Pacific Islander (*n*=0) than eighth (Black, *n*=72; Hispanic, *n*=15; Pacific Islander, *n*=1) and ninth grade (Black, *n*=269; Hispanic, *n*=51; Pacific Islander, *n*=4) Algebra I and the district (Black, *n*=6331; Hispanic, *n*=4348; Pacific Islander, *n*=61). The biggest difference is in the

Black enrollment between seventh grade Algebra I and ninth grade Algebra I. Seventh grade Algebra I had a 1.7% or 4 student average Black enrollment and ninth grade Algebra I had a 9.5% or 270 Black student enrollment for a difference of 7.8 percentage point difference.

Table 30

Grade Level Algebra I Racial Frequency

Grade Level Group	Asian		Black		Hispanic		Indian		Pacific Islander		White	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Seventh Grade	11	4.60	4	1.70	0	.00	1	.40	0	.00	221	93.20
Eighth Grade	50	3.10	72	4.40	15	.90	2	.10	1	.10	1494	91.40
Ninth Grade	38	1.30	269	9.50	51	1.80	14	.50	4	.10	2465	86.80
District	1816	1.80	6331	6.60	4348	4.50	208	.20	61	.10	80316	83.20

Note. % = percent of total enrolled in Algebra I at grade level and in District.

Table 31 breaks down grade level performance by racial groups. In looking at these groups and making comparisons, groups with only one student were not included in comparisons. Asian students had the highest ACT mathematics scores in the seventh (*n*=11, *M*=31.18, *SD*=3.34) and eighth (*n*=50, *M*=26.68, *SD*=3.40) grade Algebra I grade level groups and the highest expected course pathway completion in seventh (*n*=11, *M*=.95, *SD*=.08) and ninth (*n*=35, *M*=1.00, *SD*=.23) grade Algebra I grade level groups. Black students in seventh grade Algebra I grade level group (*n*=4) had the highest EOC level (*M*=4.00, *SD*=.00). This racial group had the lowest EOC level in eighth (*M*=3.47, *SD*=.61) and ninth (*M*=2.43, *SD*=.99) grade Algebra I grade level group. Black students also had the lowest expected course pathway completion for seventh (*M*=.86, *SD*=.15) and eighth (*M*=.89, *SD*=.22) grade Algebra I grade level groups. This is one of the most underrepresented groups in seventh grade Algebra I along with Hispanic students. Hispanic students in eighth grade Algebra I grade level group (*n*=15) performed toward to the top of the average of the grade level group in all three performance areas. In ninth grade Algebra grade level group, Hispanic students (*n*=51) performed second lowest on ACT mathematics (M=17.88, SD=2.75) and second highest on EOC level (*M*=2.74, *SD*=.68). The one Indian student in seventh grade Algebra I grade level group had the lowest ACT mathematics (*M*=25.00) and expected course pathway completion (*M*=.72), however the student had one of the highest EOC levels (*M*=4.00). In the ninth grade Algebra I grade level group, the Indian racial group (*n*=14) averaged the lowest expected course pathway completion (*M*=.82, *SD*=.24). Pacific Islander students (*n*=4) had the highest ACT mathematics score (*M*=20.67, *SD*=2.52) in the ninth grade Algebra I grade level group, as well as the highest EOC level (*M*=3.50, *SD*=1.29), however the one Pacific Islander student in the eighth grade Algebra grade level group had the lowest ACT mathematics score (*M*=18.00) and EOC level (*M*=2.00).

Table 31

Grade Level Performance by Race

Algebra I Grade Level	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Seventh Grade									
Asian	11	31.18	3.34	11	3.91	.30	11	.95	.08
Black	4	30.75	2.36	4	4.00	.00	4	.86	.15
Indian	1	25.00	-	1	4.00	-	1	.72	-
White	216	29.58	3.54	219	3.85	.44	221	.90	.19
Eighth Grade									
Asian	50	26.68	3.40	49	3.63	.52	782	.93	.21
Black	66	23.17	3.58	66	3.47	.61	72	.89	.22
Hispanic	13	24.69	2.87	14	3.64	.50	15	.93	.20
Indian	2	24.00	.00	2	3.50	.71	2	.89	.14
Pacific Islander	1	18.00	-	1	2.00	-	1	.91	-
White	1458	25.68	3.68	1462	3.64	.52	1494	.94	.19
Ninth Grade									
Asian	35	19.91	3.49	31	2.68	.83	38	1.00	.23
Black	209	17.77	3.18	233	2.43	.99	269	.85	.28
Hispanic	43	17.88	2.75	46	2.74	.68	51	.84	.24
Indian	10	18.90	3.25	13	2.46	.66	14	.82	.24
Pacific Islander	3	20.67	2.52	4	3.50	1.29	4	.85	.26
White	2030	19.73	3.59	2317	2.73	.79	2465	.90	.24

Student's family socio-economic status is reported through lunch status. Table 32 shows the average percentage of enrolled students in each grade level group that qualify for free or reduced lunch status based on their family's household income. The district's overall average during the same time period was 18.90% of students qualified for free or reduced lunch. All grade level groups in the study had a lower enrollment percentage than the district average. Seventh grade Algebra I grade level group had the lowest percentage enrollment that qualified for free or reduced lunch program with only 4.70% or 11 students. This was 11.7 percentage points lower than the ninth grade Algebra I grade level group (*n*=468) and 2.4 points below eighth grade Algebra I grade level group (*n*=116).

Table 32

Grade Level Algebra I Lunch Status

	Free and Reduced	
Grade Level Group	*n*	%
Seventh Grade	237	4.70
Eighth Grade	1634	7.10
Ninth Grade	2841	16.40
District	93080	18.90

Note. % = percent of total enrolled in Algebra I at grade level and in District.

Table 33 shows in the seventh grade Algebra I grade level group (*n*=237), students in the free and reduced lunch program (*n*=11) outperformed students in the standard lunch program (*n*=226) when looking at ACT mathematics. Students who qualified for free lunch (*M*=3.87, *SD*=.35) performed at the same EOC level as standard lunch students (*M*=3.87, *SD*=.39). Students who qualified for reduced lunch (*M*=3.00, *SD*=1.73) scored lower on EOC level than the free and standard lunch students. These same students had the highest expected course pathway completion in the seventh grade (*M*=.99, SD=.16) Algebra I grade level group. In the eighth and ninth grade Algebra I grade level groups, the standard lunch program students (*n*=3891) out performed free and reduced lunch program students (*n*=584) in all performance measures, ACT mathematics, EOC levels, and expected course pathway completion, with the free lunch program students scoring the lowest across all measures and grade levels.

Table 33

Grade Level Performance by Race

Algebra I Grade Level	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Seventh Grade									
Free	6	30.50	3.02	8	3.87	.35	8	.85	.20
Reduced	3	30.00	5.57	3	3.00	1.73	3	.99	.16
Standard	223	29.63	3.53	224	3.87	.39	226	.90	.19
Eighth Grade									
Free	66	24.27	3.51	74	3.49	.60	76	.85	.24
Reduced	40	24.55	3.64	40	3.50	.56	40	.93	.22
Standard	1484	25.68	3.70	1480	3.65	.52	1518	.94	.19
Ninth Grade									
Free	252	18.20	3.41	335	2.51	.90	362	.81	.26
Reduced	87	18.98	4.14	97	2.62	.82	106	.89	.25
Standard	1991	19.71	3.55	2212	2.73	.79	2373	.91	.23

The final pattern to review is that of special education and gifted enrollment in each of the Algebra I grade level groups. Those enrollments are shown in Table 34 along with the district average percentage enrollment during the same time period. For special education, as indicated with IEP for Individualized Education Plan, seventh (*n*=1) and eighth grade (*n*=15) Algebra I grade level group had the lowest enrollment with seventh grade12.5 points below the district average and eight grade 12 points. Ninth grade (*n*=290) was closest to the district average with the its IEP enrollment 2.7 points below the district. In reviewing participation in the gifted program, seventh grade Algebra I grade level group had the highest enrollment of gifted students with 9 points over the district average. Both eighth and ninth grade were under the district average with ninth grade Algebra 4.5 points below the district gifted average.

Table 34

Grade Level Algebra I Programs and Services

	IEP	Gifted
Grade Level Group	%	%
Seventh Grade (*n*=237)	0.4	13.9
Eighth Grade (*n*=1634)	0.9	2.4
Ninth Grade (*n*=2841)	10.2	0.4
District (*n*=93080)	12.9	4.9

Note. % = percent of total enrolled in Algebra I at grade level and in District. IEP = Individualized Education Plan, indicates a student's participation in special education

Table 35 shows the performance of students in the special education and gifted programs separated by the Algebra I grade level groups. Students who were enrolled in special education in eighth (*n*=15) and ninth grade (*n*=290) Algebra grade level groups performed at lower levels on ACT mathematics (*M*=25.17, *SD*=4.88; *M*=17.71, *SD*=3.41) and EOC level (*M*=3.40, *SD*=.74; *M*=2.30, *SD*=.95) and had lower expected course pathway completion levels (*M*=.85, *SD*=.24; *M*=.69, *SD*=.27) than students enrolled in regular education. At the seventh grade Algebra I grade level group, there was one special education student who outperformed the average score for regular education students in ACT mathematics (*M*=30.00) and EOC level (*M*=4.00), however the expected course pathway completion was lower by .22 points.

Students in the gifted program (*n*=83) consistently outperformed non-gifted students (*n*=4629) in all three performance areas in all Algebra I grade level groups. The biggest differences occurred in the ninth grade Algebra I grade level groups for ACT mathematics and EOC levels. Gifted students averaged a higher ACT mathematics by 3.37 points and a higher EOC level by .30 points in ninth grade Algebra I grade level group. The biggest difference (.09) in expected pathway completion occurred in seventh grade Algebra I grade level group in gifted over non-gifted students.

Table 35

Grade Level Performance by Programs and Services

Algebra I Grade Level	ACT Mathematics Score			EOC Level			Pathway Completion		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Seventh Grade									
IEP	1	30.00	-	1	4.00	-	1	.68	-
No IEP	231	29.66	3.53	234	3.85	.43	236	.90	.19
Gifted	33	31.73	2.92	33	4.00	.00	33	.98	.15
Non Gifted	199	29.32	3.51	202	3.83	.46	204	.89	.19
Eighth Grade									
IEP	12	25.17	4.88	15	3.40	.74	15	.85	.24
No IEP	1578	25.59	3.70	1579	3.63	.52	1619	.94	.19
Gifted	38	28.53	3.67	38	3.74	.45	39	.97	.14
Non Gifted	1552	25.52	3.68	1556	3.63	.53	1595	.93	.19
Ninth Grade									
IEP	187	17.71	3.41	267	2.30	.95	290	.69	.27
No IEP	2143	19.67	3.56	2377	2.75	.78	2551	.92	.22
Gifted	8	22.88	4.12	10	3.00	.82	11	.92	.23
Non Gifted	2322	19.51	3.58	2634	2.70	.81	2830	.89	24

Note: IEP = Individualized Education Plan, indicates a student's participation in special education

When reviewing academic performance and demographic patterns comparing student groups enrolled in Algebra I at different grade levels, there are definitely patterns to be discussed such as accelerated minority students outperforming white accelerated students on ACT mathematics by an average 1.11 points, however underperforming on the expected course pathway completion. Accelerated special education students were able to performance on an almost equal level with regular education students, but again, were underperforming on expected course pathway completion. These patterns indicate are samples that indicate the null hypothesis would be rejected.

Summary

These findings reflect academic and demographic patterns of students enrolled in Algebra I in either seventh, eighth, or ninth grade and graduated during the years between 2015 and 2020. Academic performance focused on ACT mathematics scores, EOC levels, and expected coursework pathway completion. The findings first reviewed the extent to which students in the different Algebra I grade level groups completed the expected mathematics coursework pathways. Expected pathway completion was also examined by demographic groups (gender, ethnicity, SES, and enrollment in programs and services) to determine any evident patterns that occurred between grade level groups and/or demographic groups. Additionally, findings examined academic performance patterns, including demographic groups, of students enrolled in seventh grade Algebra I as the enrollment increased significantly over the years. The final area in which this section highlighted performance and demographics patterns was between the three Algebra I grade level groups of seventh, eighth, and ninth grade when students were enrolled in Algebra I. Attention was placed on how demographic groups performance compared at each grade level. The implications of these findings will be further discussed in Chapter 5.

CHAPTER 5

CONCLUSION

Algebra I has long been the gateway course for students to access higher level mathematics courses in high school and beyond (Loveless, 2008). Due to concerns over U.S. student performance on international assessments as reported by the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), a national push for eighth grade algebra was initiated along with citing a need to provide equity for low-income students and student of color. Since the time of the push for algebra for all, states have seen a large number of students enrolled in Algebra I in eighth grade. Some students have shown positive effects and some students have, in fact, shown negative effects from this push as they were likely underprepared for Algebra I in eighth grade. Subsequently, there has been an increase in the number of students taking Algebra I at the seventh-grade level as more and more students were enrolled in Algebra I in eighth grade.

This study has investigated the patterns students enrolled in Algebra I in seventh, eighth, and ninth grade in a suburban district over six years through three research questions and hypotheses. During the six-year period, the enrollment in seventh grade Algebra I increased by 2875%. The findings discussed in this chapter examine patterns that occurred academically as this enrollment increased as well as demographically by looking at course pathways and how these students compared to students enrolled in Algebra I in eighth and ninth grade.

Summary of Findings

The study's findings examined the extent to which students completed an expected course pathway based on the grade level enrollment of Algebra I and achievement on ACT mathematics and End of Course (EOC) exam levels. These findings included breakdowns of grade levels of when students took Algebra I, graduation years, as wells as demographic groups. The summary of these findings can be found in Table 36.

Table 36

Summary of Findings

Question	Findings
Question 1: Based on the course pathway taken among students who took Algebra I in seventh, eighth, and ninth grade and graduated between the years 2015-2020 what are the student academic patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)*?*	• Students who took seventh grade Algebra I did not complete as much of the expected course pathway as students who took eighth grade Algebra I, although students who took eighth or ninth grade Algebra I were still able to take advanced courses and did so by completed beyond the expected pathway. • Females typically completed more of the expected pathways than males, however more males enrolled in AP Calculus AB at each grade level. • Asian students completed more of the course pathways than any other groups of students. • Black students along with low socio-economic (SES) students and special education students had the largest percentage of students who did not complete the expected pathway. • All Black students who took Algebra I in seventh grade enrolled in AP Calculus AB compared to only 63% of White students. • The enrollment in AP Calculus AB over the six-year period declined in students who took Algebra I as a seventh or eighth grader. • As expected, the more students completed expected course pathways, the performance on ACT mathematics and EOC levels increased.
Question 2: *As the number of students enrolled in Algebra I in seventh grade increased in graduating classes of 2015 through 2020, what were the*	• As the enrollment increased in seventh grade Algebra I, the academic performance decreased in ACT Mathematics, however there was no significant difference between the years for EOC levels and pathway completion.

Question	Findings
student academic performance patterns (i.e., Algebra I End of Course (EOC) exam scores and ACT mathematics scores) and demographic patterns (i.e., gender, ethnicity, SES)?	• Males outperformed female on the ACT mathematics in this group consistently over the years even as the scores went down. • The demographics of the seventh grade Algebra I classes did not match that of the district. Minority, low SES, and IEP students were very much underrepresented. • Asian, Black, low SES and IEP students outperformed the White students on ACT mathematics and EOC levels when enrolled in seventh grade Algebra I. Asian student completed more pathway than White students, however, Black, low SES and IEP students completed much less of the pathway.
Question 3: *How did student academic patterns (i.e., Algebra I End of Course (EOC exam scores and ACT mathematics scores), and demographic patterns (i.e.,, gender, ethnicity, SES) compare between students enrolled in Algebra I in seventh grade to those who were enrolled in Algebra I in eighth or ninth grade and graduated between the years 2015-2020?*	• While seventh grade Algebra I student outperformed students in eighth and ninth grade Algebra I, eighth grade Algebra I students completed more of the expected pathways. • Females complete more of the pathway in the eighth and ninth grade groups while males outperform in ACT mathematics and EOC level at all grade levels. • Black students are underrepresented in the seventh and eighth grade Algebra I groups and overrepresented in the ninth grade Algebra I group. • In seventh grade Algebra I, Black students outperform White students but do not complete the pathways. In eighth and ninth grade Algebra I, Black students have the lowest performance on ACT mathematics and EOC levels and are still not completing pathways. However, eighth grade is the year Black students have the highest rate of pathway completion. • Special education students performed almost equal to regular education student on ACT mathematics in eighth grade. Their highest rate of pathway completion occurred in eighth grade.

There are limitations to any generalizations of these findings. These limitations would include similar Midwestern, suburban, predominantly White, school districts and districts with a seventh grade Algebra I option.

Conclusions

The findings led to distinct patterns that evolved as performance overall and that of specific grade level and demographic groups were examined. There were three main patterns that became evident as conclusions from this study.

1. Students enrolled in the seventh grade Algebra I course increasingly were not completing the expected pathway of enrolling in AP Calculus BC by graduation and their performance were also seeing a decline as the number of students enrolled increased.

It is alarming to see, in a class where one of the primary goals was for students to take AP Calculus before graduation, only 65% of the students enrolled in seventh grade Algebra I enrolled in AP Calculus AB. As the enrollment increased in seventh grade Algebra I, the enrollment in AP Calculus AB decreased. This raises the question, are many students enrolled in seventh grade Algebra I not prepared for the rigor of the acceleration at such an early stage and end up not pursuing the elusive AP Calculus course?

There is a concern for students who are placed in seventh grade Algebra I with a one test score or not looking deeper at students' through a lens of multiple variables, but instead as an effort to fill a class. This concern includes students being placed when they are perhaps not ready as well as not identifying students who truly are ready for the acceleration of mathematics.

2. Students enrolled in the eighth grade Algebra I course had a higher rate of pathway completion along with students who completed beyond expected pathway and continued to have ACT mathematics and EOC performance that was higher than national and state averages.

In looking at all of the patterns, accelerating students into eighth grade Algebra I had the most positive impact on students with continued advanced course completion and academic performance. This seems to be the better grade level for a more generalized acceleration program with its successful patterns overall. These students did not skip as much content in order to be placed in this accelerated pathway and were most likely better prepared with foundational skills.

3. There was a disproportionate number of minority and special populations represented in seventh and eighth grade Algebra I groups. However, Black, low SES, and special education students in what would be considered the accelerated pathways performed either better or equal to White, standard SES, and regular education students on ACT mathematics and EOC levels, but fell short on the pathway completion.

Regardless of the grade level, the disproportionality of minorities, low SES, and special populations in the seventh and eighth grade Algebra I classes is something that more awareness and priority should be given to ensure there is much more equity in the acceleration programs. There is a question regarding placement procedures and how students, particularly minority, low SES and special population students, are identified for acceleration in mathematics.

Students in these groups who were placed in the in the seventh grade Algebra I course showed they have the ability to maintain the high performance expected of students in this placement, however they need to be supported throughout their placement in order to maintain enrollment in the accelerated courses and foster pathways that are fitting for their college and career goals.

Minority students, particularly Black students, placed in eighth and ninth grade Algebra I have larger gaps in achievement compared to White students. This raises another question regarding minority achievement. If students are placed correctly, how do minority student outperform in seventh grade Algebra I, but are then the lowest performing students in eighth and ninth grade Algebra I?

Discussion and Implications

It is important to connect these finding to the current literature while discussing implications and final conclusions. The first conclusion regarding seventh grade Algebra I students and the decline in achievement and pathway completion as the enrollment numbers increased dramatically could be related to whether or not students are ready for Algebra I at that grade level. The National Association for Gifted Children emphasizes that acceleration is based on "readiness and motivation" (NAGC, 2004, para.1). There are several variables that have been discussed as important for identifying students for accelerated programs including mathematics. Liang et al. (2012) studied 625,000 eighth grade students enrolled in Algebra I between 2003-2008 and found the number of students enrolling in advanced math classes decreased as the students moved into high school's more advanced math courses.

Renzulli and Gaesser (2015) emphasize the importance of above average ability, task commitment, and creativity. Gavin (2005) describes a mathematically promising student as "…a function of ability, motivation, belief, and experience or opportunity" (p. 25). Researchers indicate the importance of using multiple variables to identify students for acceleration.

The students in this study were identified through a placement test given during the spring of their sixth-grade year. Multiple variables were not used each year to ensure students were truly ready for such an advanced course at seventh grade. There continued to be a push for more students each year to be enrolled in the seventh grade Algebra I course. Although students in the seventh grade Algebra I grade level group were extremely bright students, as evident by their ACT mathematics scores and EOC levels, when students are placed into the course without the necessary foundations or fundamentals, frustration can ensue down the line causing students to potentially end the pathway early, be forced to retake courses, or perhaps not enjoy math as much as before.

The second conclusion regarding eighth grade students in Algebra I having the highest course pathway completion rate while maintaining an ACT mathematics score and EOC level that was well above national and state averages connects with several studies showing the positive effects of eighth grade algebra. A study by Spielhagan (2006) showed students who took algebra in eighth grade stayed in the advanced math pipeline longer. Assouline and Lupkowski-Shoplik (2005) discussed the importance and value of providing algebra to eighth grade students. It is important to also point out there are also more recent researchers who have found some negative effects of having students taking Algebra I in eighth grade when the practice is to have all eighth-grade students enrolled (Liang et al., 2012; Clotfelter er al., 2012; Penner et al., 2015). Based on these findings, the district seems to have a strong eighth grade Algebra I program that is providing students with the foundation for continued success in advanced courses throughout high school by having the highest course pathway completion. There are also students who have taken courses beyond the expected pathway. These students have shown to have a solid mathematics foundation and have developed a desire for more mathematics than the expected pathway and make room in their schedules for additional math courses. This can be done when a students has a particular college or career goal which requires more mathematics courses.

In discussing the third conclusion, the overall theme is equity. The conclusion is that there was a disproportionate amount of minority, low SES, and special education students represented in the seventh and eighth grade Algebra I classes through the six-year study. This trend seems to have been a part of accelerated Algebra I for decades. Smith (1996) studies students with early access to algebra in eighth grade and noted disproportionate numbers of low socioeconomic students enrolled in the eighth grade algebra course. Smith made recommendations at that time for policy in order for early Algebra I to be a more inclusive opportunity.

Interestingly, while the represented number of these students was low, Black, low SES, and special education students outperformed White, mid/high SES, and regular education students on the ACT mathematics and EOC levels, however, were much lower in completing the course pathways. While the number of these students is low compared to other groups, it is important to note their success in the accelerated mathematics courses. It is evident these minority groups are capable of being successful in a challenging class, however the program is not as diverse as it could be. By not ensuring equitable access to these higher-level math courses, the educational gap for minority, low SES, and special education students will continue to widen. Studies showed students who are placed in lower tracks, particularly minority and low SES students, do not make the same gains students do in the higher tracks. Careful consideration needs to be made when using any type of tracking for mathematics (Ventakatakrishnan & Wiliam, 2003; Ireson & Hallam, 1999, Gamoran, 1992). Researchers, Assouline & Lupkowski-Shoplik (2011) along with Gavin (2005) point to the importance of using multiple variables in identifying students for accelerated programs to ensure diversity. NCTM (2016) recommends including students who show an exceptionally high interest in mathematics, not simply a high assessment score.

The results from this study help to highlight patterns that may be cause for concern in the practice of placing students early into Algebra I in seventh or eighth grade. The results show a decline in performance and growth needed in the area of equity. These results are easily applied to other suburban districts where there are not a lot of choices for students who are high performing to attend elite or private high schools. This district is located at a distance far enough away from many of the elite urban schools, that it does not lose its top performing students to other elite schools.

Recommendations for Practitioners

Based on findings, the following recommendations are suggested for practitioners when developing a mathematics program that includes accelerating students to Algebra I before ninth grade.

1. Careful consideration should be given before offering an Algebra I course at seventh grade to include purpose and goals of the course. The focus should be on student needs. Seventh grade Algebra I should be reserved for exceptional few students who have shown clear readiness for such a high level of abstract mathematics at an early grade.
2. If offering an Algebra I course at seventh grade, curriculum and assessment directors should utilize multiple variables for identifying student for acceleration to ensure students are fully prepared. These variables could include standardized tests like the Iowa Test of Basic Skills (ITBS) to measure what a students has learned and determine instructional needs; a cognitive test to measure abstract

reasoning problem solving or working memory; an aptitude test to measure the potential for future performance like the Iowa Algebra Aptitude Test (IAAT); and a teacher rating like the Scales for Rating the Behavioral Characteristic of Superior Students (SRBCSS) that allows for teachers to rate behaviors regarding mathematics (Renzulli & Gaesser, 2015; Assouline & Lupkowski-Shoplik, 2011; Gavin, 2005).

3. Curriculum directors along with mathematics instructors should help to foster interest in mathematics with minority and low SES students along with the use of multiple variables to identify students for accelerated Algebra I and ensure equity and diversity. Identification should be ongoing and fluid (Gavin, 2005). It is important for students to have input at this point as well. Students with a passion and drive for mathematics should be able to advocate for themselves and their own placement.
4. Develop a clear communication for parents, particularly non aggressive parents, regarding options and pathways for students in different college and career pathways and the necessary mathematics courses to reach the goals. District counselors, district career and technical education representatives, college admissions officers, and curriculum coordinators would be responsible for this communication and ensuring all parents receive this information and have a clear understanding of option available to students regarding mathematics pathways.
5. Districts should have a plan for supporting accelerated students in order for students to complete course pathways and continue to be successful academically

after the initial acceleration. Students should be monitored regularly (Gavin, 2005). Monitoring would include:

- student and parent input regarding goals,
- college admission officers regarding major requirements
- state education department regarding mathematics requirements with possible adjustments

Recommendations for Policy

In order for there to be consistency and a closure in gaps for underrepresented students in mathematics programs that provide challenging, quality programs for all promising mathematical students, the following are recommendations for state and district education policy makers.

1. Districts should work together with surrounding districts to develop course pathways, clear identification processes, and prerequisites for enrolling students into accelerated mathematics pathways.
2. In order to take some of the guesswork out of the identification process, a district, education area, or statewide process developed by educator and administrative representatives from multiple buildings, districts and areas.
3. Districts and states, in order to ensure continued program success, should develop an evaluation program that will report students' progress through the program with action plans in place for students who begin to show signs of struggle.

Recommendations for Future Research

Additional research regarding the success and long-term effects of early acceleration of students into Algebra I is recommended. There are several questions that are beyond the scope of this study and research questions that would suggest a need for future research.

1. What is causing students enrolled in seventh grade Algebra I to have a lower pathway completion rate than students enrolled in eighth grade Algebra I?

   This question would require a qualitative study in which the researcher would identify students not completing the pathway and doing interviews.

2. Why was the enrollment in AP Calculus AB so low for seventh grade Algebra I students if that was one of the goals for taking Algebra I so early, to allow time for more advanced courses?

   A qualitative study would be needed for this question to interview students as to their experiences.

3. What causes high performing Black and low SES students to have low pathway completion rates?

   In the current study, there was a low number of Black students enrolled in seventh grade Algebra I, therefore, in a follow up study it would be imperative to have a sample that included a larger group of minorities, including Black, students to see if this is in fact a trend. A follow up study would also need to be both quantitative and qualitative in nature to measure performance, course completion, as well as student input as to why the pathway was not being completed.

4. In looking at students enrolled in seventh and eighth grade Algebra I courses and their performance and course completion, what were the corresponding college and career paths taken?

This could be a mixed methods study to include the performance and course completion and may then need more interviews and surveys completed by students followed by interpretation by the researcher.

Next steps would include to present these findings and recommendation to leadership within the district as they review the effectiveness and equity of the current mathematics acceleration policy. In addition, it would be beneficial to present the findings and recommendations to regional and state leaderships groups through workshops and conferences that focus on mathematics and equity practices.

Concluding Remarks

In the last decade or two, there has been an increase in the number of students enrolled in Algebra I at an earlier grade level than the original intended ninth grade. What started as a movement with encouragement from a presidential administration for eighth grade Algebra I, early acceleration of Algebra I has become common place in many school districts with little guidance as to how to determine if students are prepared and how to ensure equity in the process. Programs with shallow procedures for identifying students for acceleration are more likely to leave minority and low SES students behind, widening the achievement gap.

The overall results of this study show there are some improvements to be made in the current district acceleration process to ensure student preparedness, program follow through, and equity. School districts should make it a priority to make their mathematics acceleration programs be ones in which students continue to have an interest in mathematics and continue to be successful. From the patterns found in this study, it is the hope that districts will evaluate the success and equity of their own mathematics acceleration programs and look for ways to best serve all mathematically promising students.

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APPENDIX A

Course Descriptions

WENTZVILLE SCHOOL DISTRICT
LEARNING TODAY, LEADING TOMORROW

High School

Course Planning Guide

2020-2021

Updated 2.21.2020

ALGEBRA I STRATEGIES (Course #H4037)
GRADES 9, 10, 11, 12
Two Semesters – 1 credit
Prerequisite: Teacher Placement
Note: This course is an elective and will not count towards fulfillment of the Mathematics requirement for graduation.

Algebra I Strategies is an elective course for identified students, which is designed to enhance and reinforce the skills and conceptual understandings being developed in Algebra I. Students will be engaged in learning activities that will supplement, apply, and integrate algebraic concepts. The focus of the course will be to augment skills needed to be successful in Algebra I. Students enrolled in this course must be simultaneously enrolled in Algebra I.

ALGEBRA I (Course #H4041)
GRADES 9, 10, 11, 12
Two Semesters - 1 Credit

Algebra I places a strong emphasis on linear, quadratic and exponential functions and data analysis. This foundational course is designed to prepare students to be college and career ready as well as to be successful in more advanced classes in high school. Homework should be expected regularly and a variety of other resources may be utilized. Students will be required to take the Missouri End-Of-Course Exam upon completion of this course. Students must score Proficient or Advanced on the Algebra 1 EOC to maintain eligibility for the A+ program.

GEOMETRY (Course #H4052)
GRADES 10, 11, 12
Two Semesters – 1 credit
Prerequisite: Algebra I

Geometry covers the foundational concepts of a Formal Geometry course. This course covers geometric terminology, reasoning, lines, triangles, similarity, quadrilaterals, transformations, circles, area, perimeter, surface area and volume. Emphasis will be placed on applying these concepts to problem solving situations.. A variety of resources may be utilized.

FORMAL GEOMETRY (Course #H4054)
GRADES 9, 10, 11, 12
Two Semesters – 1 credit
Prerequisite: Algebra I
Recommended: Minimum of "C" average in Algebra I

Formal Geometry covers the concepts taught in a traditional Geometry course. Geometry builds reasoning skills through inductive and deductive thinking with problem solving. Algebraic skills and concepts are applied to enhance geometric understanding. Geometry uses both coordinate and non-coordinate systems with transformation, similarity and congruence properties to explore triangles, polygons, circles and polyhedrons. Emphasis is on the development of logic, formal proofs, and algebraic applications to geometry. Some activities will require additional time outside of class. A variety of resources may be utilized.

ADVANCED GEOMETRY (Course #H4057)
GRADES 9, 10, 11, 12
Two Semesters - 1 credit
Prerequisite: Algebra I
Recommended: Minimum "B" average in Algebra I

Advanced Geometry is an in-depth study of Euclidean Geometry. Topics covered include those that are taught in Formal Geometry (non-coordinate systems with transformation, similarity and congruence properties to explore triangles, polygons, circles and polyhedrons), as well as a variety of additional advanced topics. A greater emphasis will be placed on inductive and deductive reasoning skills, formal proofs, and algebraic applications to geometry. Students will be expected to incorporate prior knowledge to solve higher-order thinking problems.

ALGEBRA II (Course #H4043)
GRADES 11, 12
Two Semesters – 1 credit
Prerequisite: Formal Geometry or Geometry

Algebra II is designed to build upon mathematical concepts and relationships studied in Algebra and
Geometry. Students will explore mathematical relationships, generate and interpret graphs, use mathematical techniques in problem solving situations, and employ the appropriate techniques and strategies (from the study of algebraic and geometric

properties) to solve equations and convert expressions to equivalent forms. A variety of resources may be utilized.

FORMAL ALGEBRA II (Course #H4044)
GRADES 9, 10, 11, 12
Two Semesters – 1 credit
Prerequisite: Advanced Geometry or Formal Geometry
Recommended: Minimum "C" average in Formal Geometry

Formal Algebra II is designed to further develop the mathematical concepts and relationships studied in Algebra I and Geometry. It will enhance the student's ability to solve algebraic equations and inequalities; explore graphing of equations and inequalities in two variables; expand upon prior knowledge of functions, including domains, and in-depth study of polynomial equations. In addition, students will gain knowledge of complex numbers, quadratic equations, sequences and series, statistics, logarithms, and logarithmic equations, as well as an introduction to trigonometric concepts. A variety of resources may be utilized.

ADVANCED ALGEBRA II (Course #H4047)
GRADES 9, 10, 11, 12
Two Semesters – 1 credit
Prerequisite: Advanced Geometry
Recommended: Minimum "B" average in Advanced Geometry

Advanced Algebra II is a fast paced course designed to further develop the mathematical concepts and relationships studied in Algebra I and Geometry. It will enhance the student's ability to solve algebraic equations and inequalities; explore graphing of equations and inequalities in two variables; expand upon prior knowledge of functions, including domains, and polynomial equations. In addition, students will gain knowledge of complex numbers, quadratic equations, statistics, and a more in-depth study of logarithms, logarithmic equations, and trigonometric concepts.

ALGEBRA III (Course #H4049)
GRADES 11, 12
Two semesters - 1 credit
Prerequisite: Successful completion of Algebra II, Formal Algebra II or Advanced Algebra II

Algebra III is a full-year course designed to enable students not yet ready for college level coursework to experience mathematics at an advanced level. This course is intended for college-bound students who are not necessarily planning to pursue a career in a mathematical, scientific, or technical field. Concepts studied include extensions of topics from Algebra II: linear, quadratic, polynomial, rational, radical, exponential, logarithmic functions and their graphs; as well as conic sections.

PRECALCULUS (Course #H4082)
Grades: 11, 12
Two Semesters - 1 credit
Prerequisite: Formal Algebra II or Advanced Algebra II
Recommended: B average in Formal Algebra II
or Advanced Algebra II
* Weighted Course

Precalculus is a rigorous course designed to prepare students for the advanced mathematics they will encounter in pursuing a career in a technical field and/or further study of mathematics through calculus. The content consists of topics covered in precalculus and advanced trigonometry. It will expand the ideas of algebraic functions covered in Formal Algebra II or Advanced Algebra II and will extend those concepts to transcendental functions and their inverses. A strong emphasis will be placed on the behavior of functions in both an algebraic and geometric setting. A minimum of one hour additional time outside of class for each hour of class time is normal at this level. A variety of resources may be utilized.

CALCULUS (Course #H4083)
Grades: 11, 12
Two Semesters – 1 credit
Prerequisites: Students must have completed Pre-Calculus with a C or better or have teacher recommendation. *Weighted Course

Calculus will address limits, derivatives, and integrals of polynomial, exponential, logarithmic and trigonometric functions, and applications of differentiation and integration. This course prepares the student to take Calculus I at the college level. Graphing calculators will be integrated throughout this course.

AP CALCULUS AB (Course #H4085)
GRADES 11, 12
Two Semesters
– 1 credit
Prerequisite:
Precalculus
Recommendation: “B” average in Precalculus
*Weighted Course

AP Calculus AB is a rigorous course designed to prepare students for the advanced mathematics they will encounter in pursuing a technical field. It will expand the ideas covered in previous courses, proving the theory and derivation of many previously learned formulas and concepts. In addition students will learn new techniques of determining function behavior. This course focuses on the operations and applications of limits, differentiation and integration. AP Calculus AB is the equivalent of Calculus I at the college level. Projects may require additional time outside of class. A variety of resources may be utilized. Upon completion of the course, students may elect to take the AP Calculus AB exam. Graphing calculators will be integrated throughout this course.

AP CALCULUS BC (Course #H4086)
GRADES 11, 12
Two Semesters – 1 credit
Prerequisite: AP Calculus AB
*Weighted Course

AP Calculus BC is a highly rigorous and college-paced course designed to prepare students for the advanced mathematics they will encounter in pursuing a technical field. AP Calculus BC will cover all of the topics in AP Calculus AB, but will include additional units of study and extensions to many of the topics found in AP Calculus AB. The course focuses on: functions, graphs and limits extending to parametric, polar and vector functions; differentiation and integration and their applications; and polynomial approximations and series. AP Calculus BC is equivalent to Calculus I and Calculus II at the college level. Projects may require additional time outside of class. A variety of resources may be utilized. Upon completion of the course, students may elect to take the AP Calculus BC exam. Graphing calculators will be integrated throughout this course.

STATISTICS (Course #H4080)
GRADES 11, 12
One Semester - 1/2 credit
Prerequisite: Algebra II or higher

Statistics is a course designed to prepare students for the statistics they will encounter in a variety of college courses. It will expand upon the ideas covered in previous mathematics courses, extending their application to inferential statistics. Topics will include the collection, synthesis, and analysis of various types of data, emphasizing applications of the normal distribution. Projects may require additional time outside of class. A variety of resources will be utilized, including (but not limited to) graphing calculators and spreadsheets.

AP STATISTICS (Course #H4081)
Grades 11, 12
Two Semesters – 1 credit

Prerequisite: Successful completion of Formal Algebra II or Advanced Algebra II *Weighted Course

AP Statistics is a rigorous course that is designed to introduce students to the major concepts and tools for collecting, analyzing, and drawing conclusions from data. Students are exposed to four broad conceptual themes: 1) Exploring Data: Describing patterns and departures from patterns, 2) Sampling and Experimentation: Planning and conducting a study, 3) Anticipating Patterns: Exploring random phenomena using probability and simulation, and 4) Statistical Inference: Estimating population parameters and testing hypotheses. Students who successfully complete the course and AP examination may receive credit and/or advanced placement for a one-semester introductory college statistics course. Projects may require additional time outside of class. A variety of resources may be utilized. Upon completion of the course, students may elect to take the AP exam in Statistics.

COLLEGE ALGEBRA (Course #H4048)
GRADES 10, 11, 12
One Semester – ½ credit
Prerequisite: Successful completion of Formal Algebra II or Advanced Algebra II with a C or higher recommended.
Note: This is NOT an alternative to Formal Algebra II; may be taken concurrently with any math course above Formal Algebra II.
*This course may be available for college credit through Missouri Baptist University. College credit is only available to students with a 3.0 cumulative GPA (per MOBap). Please see your counselor or instructor for details.
*Weighted Course

College Algebra is intended to ease the transition for the study and pace of college mathematics. The course will be an in depth study of families of algebraic functions and relations, including polynomial, exponential, and logarithmic functions as well as conic sections and matrices. Emphasis will be placed on the algebraic manipulation and problem solving found in the study of these algebraic functions and relations.

DISCRETE MATH 1 (Course #H4087)
GRADES 11, 12
One Semester – ½ credit
Prerequisite: Algebra II or higher
*Discrete Math 1 can be taken concurrently, before, or after Discrete Math 2.

Discrete Math 1 broadens mathematical concepts and ideas. The class explores mathematics not traditionally found in the high school math curriculum. This class provides an insight into what mathematics has to offer beyond algebra and geometry. Topics of study include number theory, numeration systems, math history, logic, graph theory and programming.

DISCRETE MATH 2 (Course #H4088)
GRADES 11, 12
One Semester – ½ credit
Prerequisite: Algebra II or higher *Discrete Math 2 can be taken concurrently, before, or after Discrete Math 1.

Discrete Math 2 is a course that will broaden mathematical concepts and ideas. The class explores mathematics not traditionally found in the high school math curriculum. This class provides an insight into what mathematics has to offer beyond algebra and geometry. Topics of study include the mathematics of finance, set theory, counting techniques, cryptography, election theory, and geometry.

CONSUMER MATHEMATICS (Course #H4050)
GRADES 11, 12
One Semester – ½ credit or 2 semesters – 1 credit
*Students may enter Consumer Mathematics at the beginning of either semester.

Consumer Mathematics is designed to prepare students for real-life situations encountered as a consumer and a citizen. Emphasis will be focused on working with percentages, finances, housing, shopping, travel, and income taxes. Some activities may require additional time outside of class. A variety of resources may be utilized. Consumer Mathematics is not considered a college preparatory course.

APPENDIX B

Course Pathways

Grade	**Traditional Pathway**	**7th Grade Acceleration Pathway**	**5th Grade Acceleration Pathway**
5	5th Grade Math	5th Grade Math	5th Grade Math
6	6th Grade Math	6th Grade Math	Accelerated 6th Grade Math (skip 6th grade standards, taught 7th grade standards)
7	7th Grade Math	7th Grade Math	Algebra I (skip 8th grade standards)
8	8th Grade Math	Algebra I (skip 8th grade standards)	Adv Geometry
9	Algebra I	Adv Geometry	Adv Algebra II
10	Geometry	Adv Algebra II	Precalculus
11	Algebra II	Precalculus	Calculus AB

12	Elective	Calculus AB	Calculus BC

APPENDIX C

Course Ratings

Course Ratings	
Course	**Rating**
Concepts of Algebra	1.4
Algebra I	1.5
Geometry	2.4
Formal Geometry	2.5
Adv Geometry	2.6
Algebra II	3.4
Formal Algebra II	3.5
Adv Algebra II	3.6
Algebra III	4.4
Discrete Math 1*	4.52
Discrete Math 2*	4.53
Statistics*	4.54
College Algebra*	4.55
Trigonometry*	4.56
Precalculus	4.6
Calculus	5.4
AP Statistics	5.5
AP Calculus AB	5.6
AP Calculus BC	6.6

* Semester Courses - Ratings will be divided by 2. All other ratings are for one full year course.