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Math Course Taking Patterns of Nebraska High School Students

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By

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Abstract

Math Course Taking Patterns of Nebraska High School Students
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This study explored the math course taking patterns of Nebraska's secondary students from 2014-2020 using statewide data. Three course taking patterns were identified and examined. There are nuanced differences through these pathways based and race and gender. Student success through the pathways is dependent on course placement in the first year of high school.

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Chapter 1: Introduction

Although we cannot anticipate what the future holds for our students of today, we do know that math knowledge is one of the significant gatekeepers in modern society. Today's students will need to gather information, make sense of it, discern the facts from fiction and then make decisions and develop solutions to solve the problems they face. Seemingly more than ever, students will need the skills to determine whether claims made in the scientific, economic, social, or political arenas are valid (Graham et al., 2018). In *Visible Learning for Mathematics*, authors John Hattie, Douglas Fisher and Nancy Frey go so far as to state that "people who understand mathematics have a higher quality of life" (p.1, 2017). Quantitative evidence of this statement could be taken from Forbes Top Ten Highest Earning degrees of 2022 which reflects a list of Mathematics heavy majors in engineering, computer programming, statistics and applied mathematics (Kauflin, 2022). These high-paying careers all have a common course focus on science, technology, engineering, and math classes, commonly referred to as STEM courses, and they are credited with equipping students with the skills necessary to face an unknown future with confidence. The importance of STEM education in our schools is widely accepted and documented. Rigorous math and science classes teach content and skills that are critically important along with the beneficial byproducts of resilience, grit and confidence that come from working through challenges. When students experience challenges or "productive struggle" in classes, they learn more than just subject content. They learn that struggle is a part of learning, and they develop tools to overcome challenges, therefore becoming more confident in their own abilities (Sangiovanni et al., 2020).

The choices students make about the courses they take are their own. We should not control those decisions, but as trusted school staff we are charged with providing plans or pathways of study, career counseling and transparent, reliable guidance or advice. We must also work to assure that any course taking options are available to ALL students. The options students are given in course taking are among the most powerful factors within the schools control that impact student achievement (Spade et al., 1997). Course taking is a variable within the structures of our school systems that we can impact, or shape and it matters. Students who take an advanced academic math curriculum in high school (a highest course of algebra II, precalculus, trigonometry or calculus) are about 17 percentage points more likely to go to college and about 20 percentage points more likely to start college at a four-year institution (Aughinbaugh, 2012). The current studies cite national data sets, but the purpose of this study is to provide the initial results of math and science course taking patterns of Nebraska secondary public-school students. After the critical patterns are identified and cursorily understood, recommendations for future studies will be offered.

Over the last fifty years the student population taking STEM courses has changed dramatically. STEM became a buzz word in education in the 90s and there continues to be an emphasis placed on these disciplines throughout schools in the United States today for good reason. STEM skills have documented value to individual students, but they are also viewed as valuable assets globally. STEM courses were first emphasized in US schools in the 1950s movement driven by fear, in response to the cold war. Since then, STEM has become proxy for world leadership. Governments view their population's STEM education levels as national resources and use them to assess their status in a broader international context. This perspective impacts government involvement and policy makers' support in education initiatives. STEM skills are viewed as a reflection of our country's ability to innovate and critical to our ability to remain a world leader in a rapidly changing global economy ("Elementary and Secondary Mathematics and Science Education | NSF - National Science Foundation," n.d.).

In 2013 the acronym STEM was changed to include the arts and is now commonly referred to as STEAM. (Science, Technology, Engineering, Arts and Mathematics) For the purposes of this research we will focus specifically on the Science and Math course taking data provided by the Nebraska Department of Education. The Science and Math courses we will review teach students to use critical thinking skills and develop problem solving approaches that they will need in the 21st century workforce.

The Trends in International Mathematics and Science Study, known as TIMSS, has been conducted every four years since 1995. Our fourth and eighth grade students in the US have participated in this assessment each time it has been given since its inception. The TIMSS assessment is commonly used to compare the math and science achievement of students from different countries. In the most recent TIMSS results from 2019, United States ranked 9th, out of 19 advanced economies, in both math and Science (TIMSS - TIMSS, n.d.). Based on these results, the US Federal Government has published a written strategy for STEM education in our country. Its focus is to create high quality, equitable access to STEM education for all students and position the US as a world leader in literacy, innovation, and employment.

This plan has three overarching goals. They are to:

1. Build Strong Foundations for STEM Literacy.
2. Increase Diversity, Equity, and Inclusion for STEM.
3. Prepare the STEM workforce for the future.

Since its early beginnings in the 1800s, our founding leaders in education have envisioned a public school system that would bridge all societal and economic gaps. Horace Mann believed that schools should be free and available for every citizen because education could lead to greater wealth and opportunities (Digital, n.d.). These ideals and visions have been the cornerstone of the public school system over the last two hundred years, and they continue to be part of the daily mission of educators worldwide.

Within our more recent history, education reform has made impactful and lasting changes in the system in response to societal needs. The publication of "A Nation at Risk" in 1983 turned a critical eye on the public school system and called for more rigorous coursework. It led the way for local, state and federal standards and reform efforts that have shaped today's system such as No Child Left Behind of 2001, Every Child Succeeds Act of 2015 through present plans by the Biden Administration to add two years of preschool and two years of free community college to each child's educational journey. This would be a monumental change in the traditional number of public schooling years from moving 13 to 17 years of free public-school education. Each of these educational reforms come with heated debate and commentary on their pros and cons from both sides of the political aisle. However, there can be little debate that the course taking patterns of students have changed dramatically over the last fifty years due, in part, to both the positive and negative ripple effects of these reforms. One example of these changes is the number of students who earned credit in precalculus, or calculus has more than tripled from 1982-2004 (Domina & Saldana, 2022). The percentage of students with access to high level curriculum and curricular intensification in high school has grown dramatically. As we look at these shifts in course taking patterns it is important to see which gaps have closed and where there is still work to be done to make classes accessible to all students.

In June of 2012, the US Department of Education's Office for Civil Rights authored a report called *Gender Equity in Education: A Data Snapshot*. That snapshot focused on progress made since the passage of Title IX in 1972. This report showed that enrollment distribution of males and females in Geometry, Algebra 2 and Calculus is equitable at almost exactly even distributions. It also shows although more females enroll in AP courses males just slightly outperform females on AP Tests. Recent reports show that women currently make up 50% of the STEM career workforce. Approximately 75% of the health care fields comprised of women showing an over-representation of females in those STEM related careers. Although the pathways appear to be available, women are not choosing STEM careers in engineering and computer science. There continues to be an under-representation of females in those STEM career subsets (Fry, 2021). This is noteworthy as there is an increasing demand for these high paying positions within the current job market.

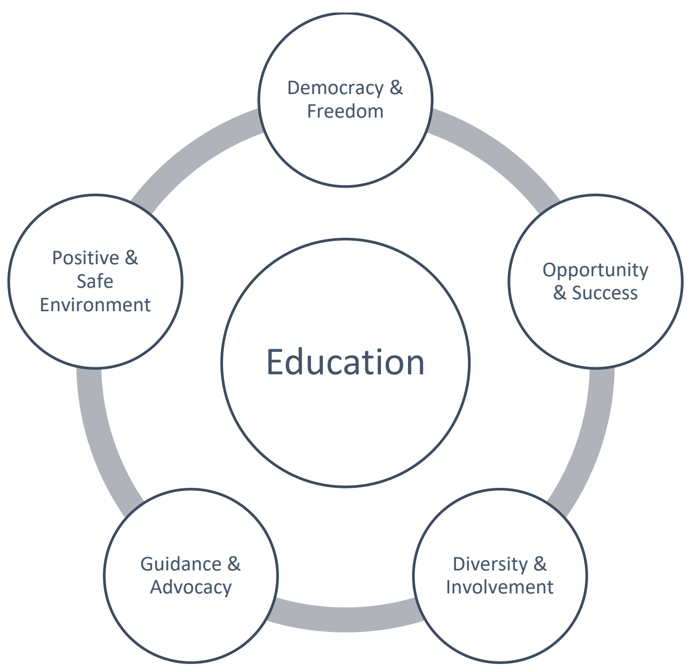
Although the course taking gap has closed between males and females, research shows that there are still race based gaps (Irizarry, 2021). This will be a reoccurring theme throughout this research. This will also be a crucial piece of our data examination as we review Nebraska's data for our final report. As educators we must continue working to identify obstacles that underrepresented students face and encourage students of all races to choose STEM courses and work toward STEM related careers.

Theoretical Framework

Former United States Secretary of Education, Arne Duncan made this Facebook post on Nov. 16th, 2012 "In America, your zip code or your socioeconomic status should never determine the quality of your education" (Duncan, 2012). Ten years later it's a statement that most educators, regardless of political affiliation, support because we understand that educational opportunities are the vehicle for student's upward socioeconomic mobility. The Social Justice Framework is grounded in the fundamental belief that all students should have educational rights to access courses that open doors to the careers and the life they desire. The following image illustrates the five principles for leadership, equity, and social justice along with the impact they have on education.

Figure 1

Five Priciples for Leadership, Equity & Social Justice in Education



Alfattal (2015)

This framework has influenced the perspective for this research. Next, each part of the framework will be explained along with a brief description of its tie to this study. The first principle, Equitable Education Opportunities and Success are Accessible to All Students (Alfattal, 2015) is really the key to the motivation behind our work. As we examine the data of course taking patterns we want to ensure that all Nebraska students have the equity and access to the courses they need for their desired career path. This principle is also reflected in the Nebraska Department of Education's mission statement. Their strategic board lists that, "ensuring all Nebraskans, across all backgrounds and circumstances, have equitable access and opportunities for success." The state defines educational equity as each student having access to the educational resources they need at the right moment, at the right level and with the right intensity (SI-Nondiscrimination and Equitable Educational Opportunities in Schools, 2022). As we work to review the course taking patterns of Nebraska students, we will be using this principle as a lens through which we view the data. We will be looking for evidence that suggests students across the state have equity in access to content they need.

The second principle highlights the importance of learning in a safe and positive classroom environment. John Hattie's (2013) work *Visible Learning for Teachers* highlights the importance of this principle. He states that both teachers and administrators must create a school climate that accepts and even welcomes errors, as an important piece that aids in learning. When students do not know the answers and are comfortable seeking help in front of peers and teachers, they feel safe in their learning space. Research indicates that math achievement in both male and female students is negatively impacted in classroom environments where bullying occurs and students do not feel safe (Konishi et al., 2010).

The third principle focuses on school staff advocating for all students. Emerging research highlights the importance of teacher attitudes, perceptions, beliefs, and actions in shaping disparities in students' educational achievement and course attainment. Despite best intentions, teachers do play a role in the perpetuation or mitigation social constructions that impact student achievement (Turetsky et al., 2021). Principles two and three are extremely impactful in course taking decisions made by high school students. When there is a climate and culture that encourages students to excel and take challenging courses, students are far more likely to take educational risks and attempt high-level challenging classes.

Principle four emphasizes the importance of teaching staff that reflects the diversity of the student population. As we currently face a nationwide shortage of teachers, it is important to note that there has been a shortage of minority teachers for several decades (Ingersoll et al., 2019). A large study of student achievement data from the Florida Department of Education published in 2015 showed a small yet statistically significant positive effect when black and white students were assigned to race-congruent teachers. This study also found that lower performing students appeared to benefit the most from having a teacher of the same race (Egalite et al., 2015). This is important as we move forward and work to correct under representation of Hispanic and African American students in the STEM courses that translate into careers in STEM related fields. This principle also has implications for universities and human resources departments at the district level as we work to recruit, train, and hire future teachers who become role models for our current students.

The final principle is that educational institutions should operate democratically with stakeholder voice in creation of policies, governance, and education. This principle reflects the collaboration between the various stakeholders in a school or school district. Districts are run by School Boards and Administrators, Parents, Teachers, and Students should all have access to processes that illicit their feedback.

If these five principles are viewed as a tire on a bicycle and each principle is a spoke on that wheel, it is easy to see that they must work in unison to function effectively. If one spoke breaks the tire loses stability and the wheel cannot work as designed, the same is true with our educational system. For our schools to function at optimal levels for our students, these five principles of social justice must be in place. John Rawls is credited with developing the Social Justice Framework in 1971. In his book "Theory of Justice: Original Edition he states, "In all sectors of society there should be roughly equal prospects of culture and achievement for everyone similarly motivated and endowed. The expectations of those with the same abilities and aspirations should not be affected by their social class" (Rawls, 1971). This rings as true today as it did then. Examining the processes, procedures, and outcomes in schools for equity is our moral, ethical, and social responsibility as educators.

Purpose of the Study

The purpose of this modified exploratory data analysis is to understand the current and past mathematics course taking patterns of secondary students across Nebraska. This information will help identify possible opportunity gaps for specific populations as well as inform practices regarding secondary course taking decisions.

Chapter 2: Literature

In his seminal work *Theory of Justice: Original Edition* John Rawls states, "In all sectors of society there should be roughly equal prospects of culture and achievement for everyone similarly motivated and endowed. The expectations of those with the same abilities and aspirations should not be affected by their social class," (Rawls, p.73, 1971). Research from Ellison and Swanson (2010) suggests that there are substantial differences in effectiveness of schools across the country and that many students achieve higher levels of achievement in math if placed in different environments.

Each district and high school across the country has the autonomy to allocate resources and structure courses as they see fit. Although there are many studies on school effectiveness and the impact it has on students' learning and development there continues to be a need for the narrowed focus on course taking patterns in math and the implications of these patterns on college and career success. Each individual district and even the schools within the same district may have different processes for placing students in courses, different attitudes toward the processes and tracks within tracks for course completion.

> *We must also make sure that, no matter where children live, they have access to quality learning environments. A child's zip code should not determine their STEM literacy and educational options* (Science, Technology, Engineering, and Math, Including Computer Science | U.S. Department of Education, n.d.).

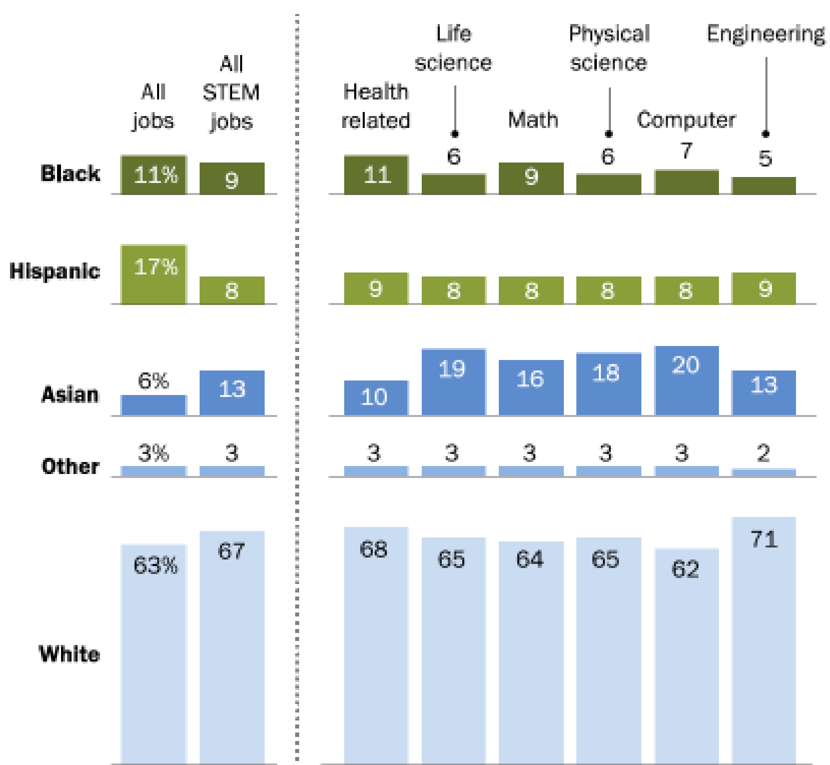
The following is a review of the literature to explain the nuances of math course taking patterns in the secondary levels and the variables affecting student choice.

Student Demographics

A review of current national research indicates that disparities continue to exist in achievement and access to high level STEM courses still exist in some populations. Nationall,y student race, gender, and socioeconomic status continue to impact course taking patterns of high school students and their career path. There are currently a greater number of White and Asian students enroll in advanced mathematics than their Hispanic and African American peers (Anderson & Chang, 2010). This trend impacts the work force with fewer Hispanic and African American students moving in to STEM related careers. Figure 3 (below) shows recent 2021 data from the Pew Research Center on the under representation of African American and Hispanic people in STEM related careers.

Figure 2

Percent of 2017-2019 Workforce and STEM Workforce



(Fry, Kennedy, & Funk, 2021)

We know that a school's socioeconomic status is one of the greatest factors that affects student achievement. Sociologist Robert Merton coined the term, The Matthew Effect, on the pattern in which those who begin with advantage accumulate more advantage over time and those who are disadvantaged become more disadvantaged over time. The common colloquialism for this scientific pattern is "the rich get richer, and the poor get poorer." It is no revelation that a student's socioeconomic status can impact student achievement. This is a factor that impacts student achievement and the courses they choose to take throughout middle and high school.

Disparities are greatest in the low socioeconomic schools that lack resources such as counselors, highly trained teachers, and college preparatory programming. Differences in course taking patterns were more extreme between the high and low socioeconomic groups than across groups compared by race/ethnicity. Students on free and reduced lunch appear to take fewer math courses, when they do, they are primarily level one courses, and they are less likely to take advanced courses (Finn, 2002).

School districts across the country have worked to successfully encourage more students to take STEM classes in high school. Although the overall number of students taking STEM classes has grown, there continues to be evidence that fewer African American students and Latino students take advanced level math courses (Dalton et al., 2007). Current reports show that the gender gap high school course taking seems to have closed and women currently make up 50% of those employed in STEM careers. This percentage is slightly above women's overall representation in the work force. Women are more likely to choose STEM careers in health-related fields and less likely to choose engineering (Fry, 2021). Over the years differences in male and female student enrollment in math courses has leveled out (Anderson & Chang, 2010). Disparities in STEM course choices occur less frequently for females as fewer women choose STEM careers. Recent studies have reported that the gender gap in course selection of high school math classes has disappeared (Crosnoe et al., 2008). Continued research in this area is needed to determine if the gender gap remains between male and females in all ethnic groups. Gender gaps do continue to appear on math tests among high-achieving students. Research shows that there is a 2.1-1 male-female ratio among students scoring 800 on the mat SAT and a ratio of at least 1.6-1 among students scoring in the 99th percentile on the PISA test in 36 out of 40 countries (Guiso et al., 2008).

Research abounds on the impact of race, ethnicity, gender, and socioeconomic status on student achievement. Another group of students that may be overlooked is the nearly 10 million students attending schools in rural areas. This group consists of nearly one-fifth of the school age children in the United States (Beeson, 2000). Districts with lower student enrollment are not able to offer as much depth and variety in their courses. Smaller schools have a smaller faculty and staff, therefore fewer adults to support students in their learning. But narrowed offerings alone do not prove to have a negative impact on students' mathematical achievement. There continues to be variation from district to district across the state in course requirements for graduation. Although schools work to help students meet the college entry credit criteria, some schools push students to higher levels and require more semesters of classes. This can result in students reaching higher level classes and gaining exposure to more difficult content. These students may be more prepared for rigorous college coursework and content. Rural High school students appear to take their last math class sooner than students in other locations. (Anderson & Chang, 2011).

Although great strides have been made over the last fifty years in access and availability of advanced math and science courses to students, there is still work to be done. The following preliminary recommendations could be made based on national data to increase student participation in advanced Math and Science Courses.

1. Summer Bridge STEM programs
2. Mentoring Programs
3. Engaging Hands-on Research Experiences
4. College Level Peer Tutoring
5. Career Counseling and Awareness
6. Drop-in Learning Centers
7. Workshops and Seminars
8. Academic Advising
9. Financial Support and Incentives
10. Curriculum and Instructional Reforms

While each of these researched strategies is beneficial for the recruitment and retention of underrepresented minority groups, they can also be beneficial for the entire student population (Tsui, 2007).

Student's Self Efficacy/Math Identity

A student's self-efficacy or belief in their own abilities can have a profound effect on their performance in any academic area. The term "Math Identity" has been defined as *"The dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the context of their lives*" (Aguirre et al., p.14, 2013). Although development of identities should be a lifelong process, the way a student feels about their own capabilities at critical points in their development can have a significant impact on the courses they choose to take, the effort they put forth and ultimately their success in a class. How individual students perceive their competencies have been found to have long lasting effects on college decisions and a student's career trajectory (Quintana & Saatcioglu, 2022). As we take a closer look at students who continue to be under-represented in high level math classes, such as African American Males, recent research shows a direct correlation between school climate and math identity of these students (Jackson et al., 2021).

There are several practices that occur daily in classroom that can begin to shape a student's math identity. Ability grouping often begins in elementary school as students are placed in small groups based on similar skills and demonstrated abilities. This practice is has been in place for over forty years in reading instruction and more recently implemented in schools as Guided Math. Although well intended, this strategy can have unintended consequences negatively impacting student confidence, perception of their own abilities and eventually effort. These practices can create mini-caste classroom systems where high achieving students are given access to more difficult content and low achieving students are given content below grade level forever losing out on the opportunity for exposure to more challenging content. The second way tracking occurs is through the actual creation of tracks and courses of varied levels of rigor in middle school and high school. Students are typically placed in math classes in sixth grade based on standardized assessment scores and fifth grade classroom performance on curriculum-based assessments and classwork. Students can take either a basic sixth grade math class or a pre-concepts course which is a prep course for pre-algebra in seventh grade followed by algebra in eighth grade.

Another impactful common practice that takes place in elementary is timed tests for basic facts. These are done to increase students' fact recall and automaticity but may have negative and long-lasting impacts on some students. Studies show that children manipulate math facts in their working memory-an area of the brain that can go off-line when they experience stress (Boaler & Zoido, 2016). When given timed tests, our working memory is impaired and math anxiety can develop. Estimates suggest that as many as one-third of all students suffer from math anxiety which can have long lasting effects. These results have documented in students as young as five years old. There seems to be a misplaced emphasis put on speed and quick completion of math tasks in our school system. To reduce math anxiety early on in students an emphasis on speed could be replaced with effort, accuracy, and diligence.

As teachers and administrators, it's important to understand various types of student identity, how they develop and the role we play in shaping them. It's important to reflect on our daily activities and work to understand the unintended consequences or messages we send students that may shape their beliefs about themselves. Positively impacting math identity of students can have long-term effects on the courses and careers students decide to pursue.

Parent Advocacy

Parents also play an important role in the course taking choices student make but they may or may not fully understand the process or the implications of each decision. The more knowledge parents have of district processes, their own school experience and education level along with their expectations for their child's future may cause them to intervene. Research proves that college-educated parents are more likely to intervene and be actively involved in their child's school choices and academic pathway.

The most influential predictor of a student's academic achievement in Math was parental expectations and aspirations for their child (Fan & Chen, 2001). Gender and ethnic differences also appeared to have a role in the influence of parental expectation on course selections (You, 2013).

Parent Deferment

There is no debating that parental involvement in a child's education can have a significant impact. As children begin school at pre-k or kindergarten parents are typically involved and supportive in their child's school in some capacity. This involvement varies from volunteering at the school, serving on the PTO, emailing principals and teachers, interacting with other parents socially or supporting their child with learning at home when content is challenging. But as students' progress through elementary grades many parents continue to stay involved eventually students are encouraged to take responsibility for their own assignments, grades, and coursework. In middle and high school students begin to make course selection choices, these choices can have long lasting ramifications on academic achievements. School staff typically make recommendations for the course placement of students in sixth and seventh grade. Parents are informed about the placement decisions being made for their child. At this point, often depending on the parent's level of knowledge regarding district processes and the transparency of placements, parents may provide input resulting in a placement change. Research shows that well educated parents are more likely to intervene, less likely to defer to school staff in the placement of their child and push their child into more rigorous courses (Useem, 1992).

Typical Math Course Taking Sequence

Initial student placements in Math and Science classes are critically important because in these content areas the classes are considered pre-requisites to one another building on the knowledge learned in the previous course. Therefore, Math and Science classes must be taken in a sequential order. These classes are also of critical importance for students as they navigate a path toward college and their career. Courses such as Algebra and Calculus are widely considered “gateway” courses. Algebra unlocks the door to geometry and higher-level math courses such as trigonometry and Calculus. Calculus is a prerequisite for entry into most science, math, and technology related majors in college (Oakes, pg.vii, 1990) A student’s placement early in middle school has the potential of placing them on a course taking pathway that determines their coursework ceiling for senior year and beyond. There is also research showing that when students are placed in math in slower or regular tracks “early” such as sixth or seventh grade, they may be forced to “decelerate” their math learning. This can result in student pathways that limit potential early and are very difficult to overcome.

Course-taking patterns of high school students are also influenced heavily by the graduation requirements set in place by state and local school districts. The most recently published State Course Requirements for High School Graduation from 2018 show that 47/50 states have defined state graduation minimum requirements. Pennsylvania, Massachusetts, and Colorado allow graduation requirements to be determined by the local school boards in each district. School districts can also require additional hours, but these are the minimum requirements for students to graduate are set by each state. The states vary from Alabama's required 24 credits (240 hours) required for graduation to Wyoming's 13 credits (130 hours).

In the state of Nebraska, all high schools have basic graduation requirements that are similar and must include a minimum of 200 credit hours; 80% of those hours must come from the core curriculum (Nondiscrimination and Equitable Educational Opportunities in Schools – Nebraska Department of Education, n.d.). These required hours can be further broken down by content area as a required 40 hours of English/language arts, 30 hours of math, 30 hours of science and 30 hours of social studies.

A typical course progression for a Nebraska student begins in middle school with some form of middle school basic math class, pre-algebra/beginning algebra course with a pathway to Algebra which can be taken prior to a student's freshman year of high school. This progression opens the door to the high school course taking sequence: Geometry, Algebra II, Trigonometry, Pre-Calculus and Calculus classes before college.

Chapter 3: Methods

This chapter includes a description of the methodology and outlines the process of data collection and analysis used for this study. This chapter describes the purpose of the study, research question, collaboration, security, data, and data analysis.

Purpose

The purpose of this modified exploratory data analysis is to understand the current and past mathematics course taking patterns of secondary students across Nebraska. This information will help identify possible opportunity gaps for specific populations as well as inform practices regarding secondary course taking decisions.

Research Questions

1. What are the secondary mathematics course taking patterns of Nebraska students?
2. Do these patterns vary by race or gender?

Collaboration

The Nebraska Education Policy Research Lab is a collaboration between the Nebraska Department of Education (NDE) and researchers at the University of Nebraska to conduct rigorous research for the purpose of developing a body of evidence-based policy solutions that can be shared and applied widely within the Nebraska education system. Locally for this project, the collaboration was specifically between two departments: Educational Leadership and Mathematics Data Science. Both departments supervised graduate student exploratory data analysis on the data set of secondary math course taking patterns. Because of the volume and complexity of the data set, the graduate student team will work closely with each other. The Educational Leadership graduate student will provide insight on the nuanced understanding of the data elements, hypothesis of outliers, and changes in reporting over the years. The Mathematics Data Science graduate student will provide expertise of complex data package software and skilled tools for big data analysis. The research team will consist of the Mathematics Data Science graduate student, the Educational Leadership graduate student (author of this dissertation), Educational Leadership graduate student peer, and supervising faculty.

Security

The data set was shared from the state department to the university team using a secure, password protected server managed by the state department. All server activity is tracked and monitored by the state department. All data activity including cleaning, reconfiguring, and execution of scripts occurs on the server. No data is downloaded outside of the server. Only the Mathematics Data Science graduate student and supervising faculty are provided individual credentials which allow server access. The credentials are managed and monitored by the state department. The university maintains signed statements of understanding data ethics and security for all credentialed individuals.

Data

The data set referenced for this modified exploratory study is provided by the Nebraska Department of Education in collaboration with the Nebraska Education Policy Research Lab. All personal identifiers were modified before the data set was shared. The data is part of regularly collected data by the state department and is used for retrospective analysis. The full data set contains student-level mathematics course enrollment by year from 2014 to 2020 including school district, race, and gender. This will be approximately 202,210 individual units of data. Analysis resulting in subpopulations less than ten will be masked.

A narrowed data set may be created with only aggregated population trends will be called the small data set. The small data set will be prepared by the Mathematics Data Science graduate student and shared in a secure, password protected university folder using excel with the Educational Leadership graduate student. The small data set might be used for additional understanding of the data set.

Data Analysis

Exploratory data analysis (EDA) is a robust process originally described by Tukey (1977). While the research team is seeking to understand the mathematics course taking patterns without pre-conceived patterns in mind, this exploration will fall short of a full EDA. The ideals outlined in Tukey (1977) have been simplified by Fife (2020) as eight steps.

Figure 3

Exploratory Data Analysis

Step	Purpose
1. State the theoretical hypothesis	Helps to minimize fishing for statistical significance Provides a translational map from theory to data Allows users to specify their own decision criteria Invites researchers to consider preregistering hypotheses
2. Assess psychometric properties of variables	Invites researchers to think about the impact of measurement
3. Plot univariate distributions	Helps identify outliers Helps identify issues with nonnormality Assists in identifying coding errors
4. Plot a graphic to match the theoretical hypothesis	Directs focus toward the size of effects Helps identify potential problems with nonlinearity and heteroscedasticity Improves cognitive encoding of results Highlights uncertainty
5. Study residuals	Helps identify problems with normality (e.g., through histogram of residuals) Helps identify problems with nonlinearity and homoscedasticity (e.g., through a residual dependence or scale location plot)
6. Interpret parameter estimates and effect sizes	Encourages the researcher to focus on estimation before significance Puts graphical information into concrete numbers
7. Make a decison on the basis of decision criteria (if appropriate)	Assists in making a decision about significance
8. Replicate on a new data set	Encourages cumulative and reproducible science

Fife (2020)

The research team used an even more simple approach than either Tukey or Fife. With the size of the data set, Sankey diagrams and count of enrollments will be used to first understand the scope of the data. The next chapter, Results, will take the reader through the modified data exploration process and results of each next step.

Chapter 4: Results

The purpose of this research is to examine the course taking patterns of secondary students in the state of Nebraska. This chapter will present the findings of this modified exploratory data study. Two questions were addressed in this study:

1. What are the secondary mathematics course taking patterns of Nebraska students?
2. Do these patterns vary by race or gender?

There are many courses offered to middle and high school students across the state of Nebraska and the course paths students can take through high school are varied and complex. It's important to acknowledge that math courses are hierarchical, or progressive in nature. They must be taken in a proper order to ensure that learning scaffolds from one class into the next. Therefore, the sequence in which a student takes courses can provide very different learning opportunities. The earlier students take Algebra, the gatekeeper course that unlocks the door to Geometry, the more likely they are to stay on track for Pre-Calculus or Calculus courses as a senior.

The complexity of course taking patterns increases with advanced courses and additional course options as students' progress through high school. For example, there are three course options for high school Calculus: Advanced Placement Calculus AB (equivalent to Calculus I in college), Advanced Placement Calculus BC (equivalent to Calculus I and II in college), and Calculus (not Advanced Placement). Students might choose or be counseled to one of these three classes based on their previous math course performance, post high school goals, and availability in the school. This complexity does not only lie in Calculus options. Between 2014 – 2020, Nebraska schools offered 27 different math courses across the state as seen in Table 1.

Table 1
Nebraska Secondary Math Course Titles 2014 – 2020

ADVANCED PLACEMENT CALCULUS AB
ADVANCED PLACEMENT CALCULUS BC
ADVANCED PLACEMENT STATISTICS
ALGEBRA, ADVANCED
ALGEBRA, BEGINNING
APPLIED MATHEMATICS I
APPLIED MATHEMATICS II
APPLIED MATHEMATICS III
ARITHMETIC
BUSINESS MATH
CALCULUS
COLLEGE TECHNICAL MATHEMATICS
FINITE/DISCRETE MATHEMATICS
GEOMETRY
IB FURTHER MATHEMATICS-HIGHER LEVEL
IB MATHEMATICAL STUDIES
IB MATHEMATICAL STUDIES-STANDARD LEVEL
IB MATHEMATICS-HIGHER LEVEL
MATH, OTHER
MATHEMATICS, GENERAL
MATHEMATICS-MIDDLE GRADES/JR HIGH I
MATHEMATICS-MIDDLE GRADES/JR HIGH II
MATHEMATICS-MIDDLE GRADES/JR HIGH III
PRE-CALCULUS
PRE-ALGEBRA
STATISTICS/PROBABILITY
TRIGONOMETRY

With these many options for course taking, a student's mathematics journey through high school can take a multitude of paths. To observe the pathways student took, the research team represented the data using Sankey diagrams. The decision was to use the entire data set and not distinguish by year. The purpose of this was to be able to observe if there were any general patterns of course taking behaviors that visually stood out from the full data as represented by large bands in the Sankey diagrams.

Sankey Plots can be used to visualize enrollment numbers from one grade level to the next. With over twenty courses from which to select, the researchers viewed Nebraska math course student enrollment with two levels of threshold enrollments: 700 (Figure 4) and 200 (Figure 5). The following Sankey visuals demonstrate the flow of students from tenth grade through twelfth grade. The difference in the two images shows the increased number of potential paths when reducing the student enrollment threshold.

Figure 4

2014-2020 Nebraska High School Math Enrollment 10th to 11th to 12th Grade Threshold 700

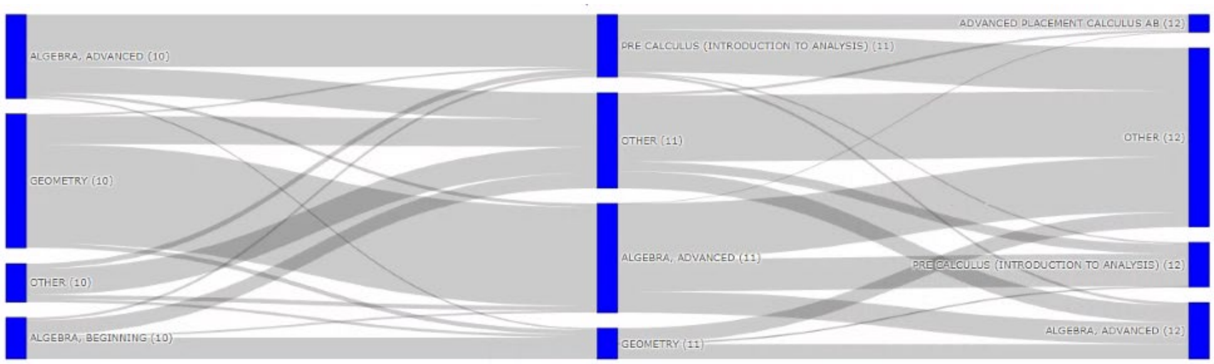
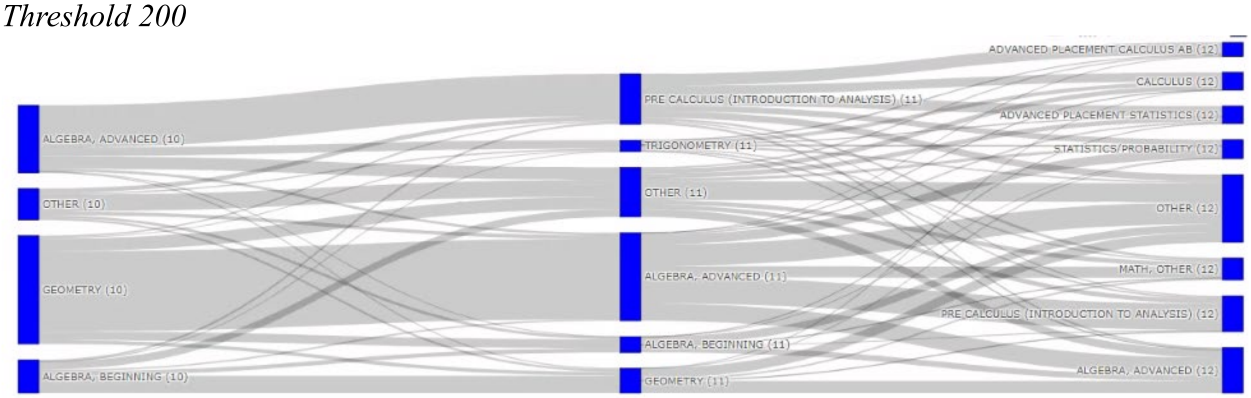


Figure 5

2014-2020 Nebraska High School Math Enrollment 10th to 11th to 12th Grade Threshold 200



The reader might also see, then, that a larger threshold is easier to read visually and can see the complexity increases when population threshold counts in a course are smaller.

Next, the research team restructured the data to be in modified graduation cohort groups. These are modified cohorts because the team included all students in a grade level of that year for that cohort. In other studies, researchers might choose to only include students who are present in the cohort for all four years of high school. The data of course enrollment from freshman to sophomore, sophomore to junior, and junior to senior was represented in Sankey diagrams for Cohort 2018 (students were 9th graders in 2014-2015 and 12th graders in 2017-2018) and Cohorts 2019 and 2020. Data was observed as a threshold of both 200 and 50. Figures 6 – 11 show these results for the single Cohort 2018. Cohorts 2019 and 2020 followed similar patterns and so are not included here.

Figure 6
2018 Cohort Sankey Flows From 9th to 10th Grade
Threshold 200

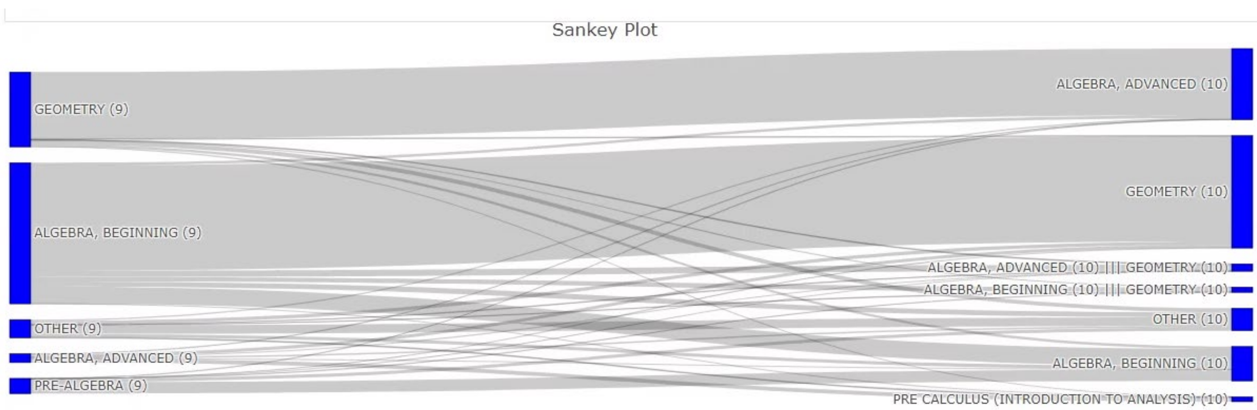
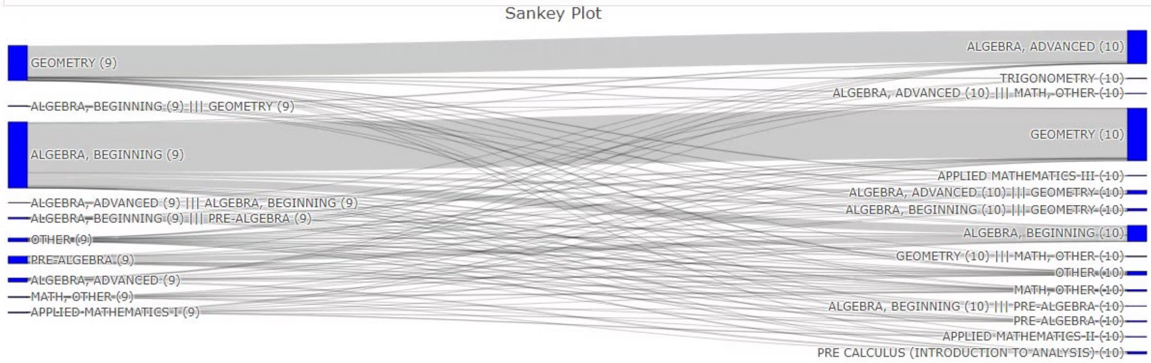


Figure 7

2018 Cohort Sankey Flows From 9th to 10th Grade
Threshold 50



The Sankey diagrams suggest two, possibly three courses that most 9th graders take. We can also observe the 10th grade courses selected by 9th graders. With a threshold of 200, some courses are also observable in the 10th to 11th grade course selection as typical choices.

Figure 8

2018 Cohort Sankey Flows From 10th to 11th Grade
Threshold 200

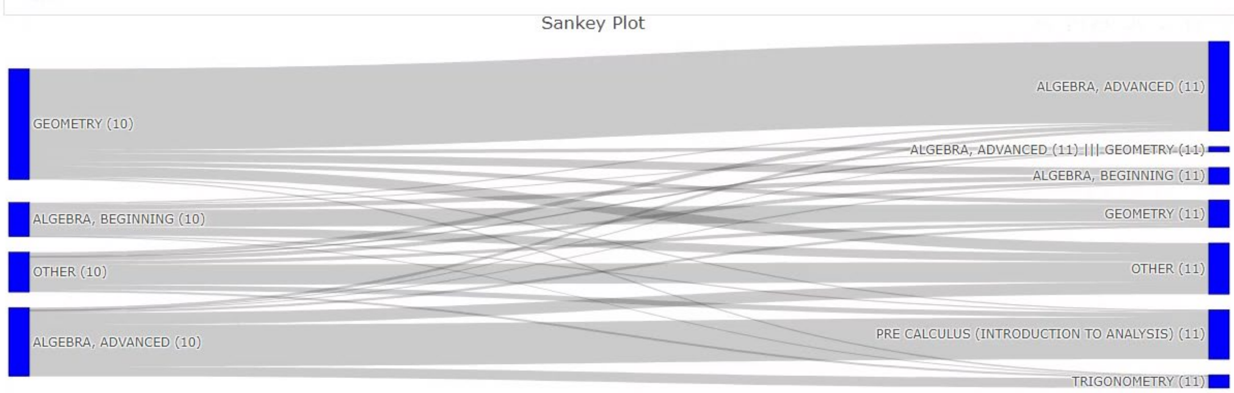
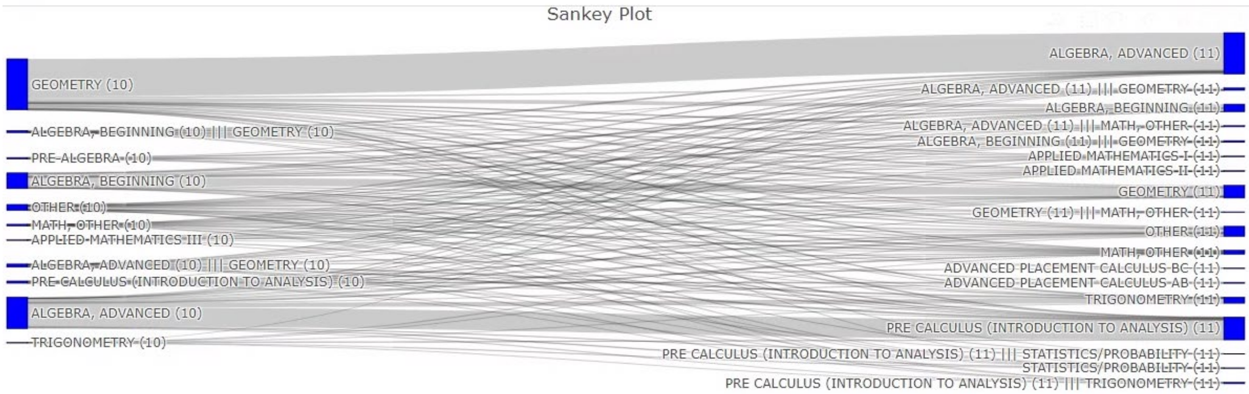


Figure 9
2018 Cohort Sankey Flows From 10th to 11th Grade
Threshold 50



Figures 10 and 11, however, demonstrate the complexity of course selection from 11th to 12th grade. Even at a threshold of 200, 12th grade course selection is varied. It is even more complex at the threshold of 50.

Figure 10
2018 Cohort Sankey Flows From 11th to 12th Grade
Threshold 200

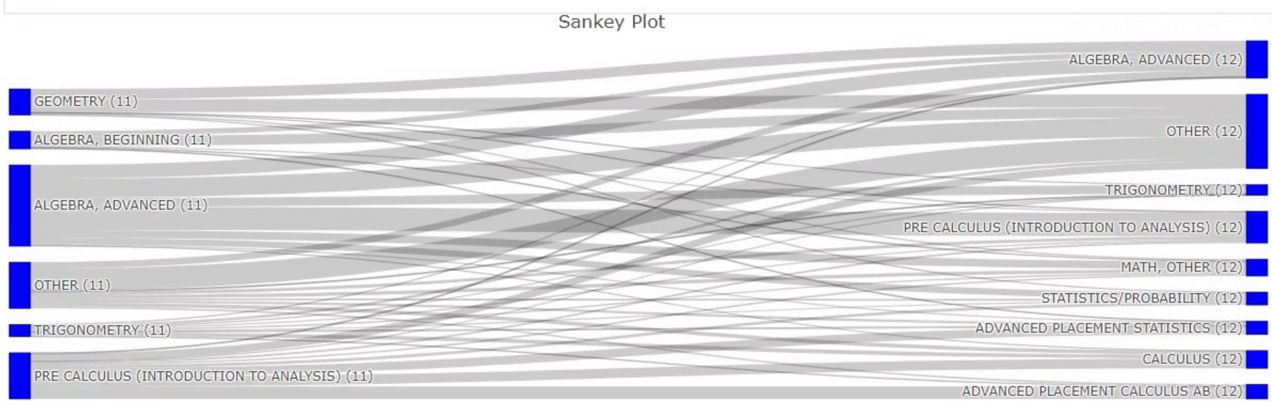
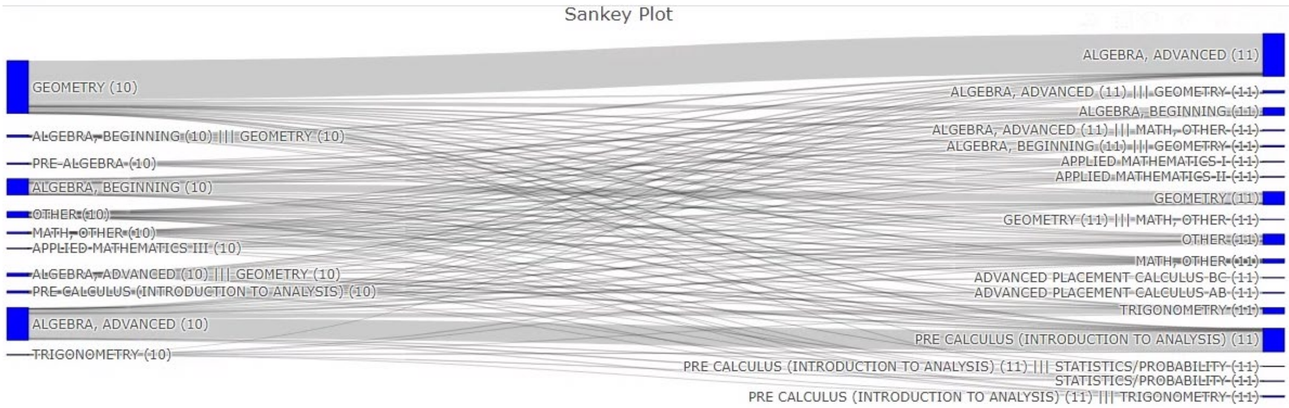


Figure 11
2018 Cohort Sankey Flows From 11th to 12th Grade
Threshold 50



Although the paths students take through their high school courses is individualized, there are some typical pathways that can be identified for most students. This study will refer to these pathways as Path A, Path B and Path C. These pathways represent what are considered an on-track group, a slightly advanced group, and below average student groups.

Path A-On Track Course Progression

9th Grade Beginning Algebra	10th Grade Geometry	11th Grade Advanced Algebra	12th Grade Precalculus and Trigonometry

Path B-Slightly Advanced Course Progression

9th Grade Geometry	10th Grade Advanced Algebra	11th Grade Precalculus and Trigonometry	12th Grade Calculus, AP Calculus AB, and AP Calculus BC

Path C-Slightly Behind Course Progression

9th Grade Prealgebra	10th Grade Beginning Algebra	11th Grade Geometry	12th Grade Advanced Algebra

Ninety-one percent of course enrollments are accounted for in one of these three pathways. However, by senior year the classes in these pathways account for just a bit over half of all math course enrollments.

The researcher next reviewed course enrollments of a single grade level over multiple years. The following tables show real enrollment numbers to illustrate that the majority of students take courses represented through the three established pathways A, B and C in ninth grade. These tables also show the difference in pathway enrollments in 10^{th}, 11^{th} and 12^{th} grade.

Table 2

Nebraska 9^{th} Grade Mathematics Course Enrollment Over Six Years, 2014-2020

	Academic Year					
Course Name	20142015	20152016	20162017	20172018	20182019	20192020
ALGEBRA, BEGINNING (9)	12,775	12,811	13,203	12,831	13,179	14,026
GEOMETRY (9)	6,438	6,466	6,582	6,547	7,189	1,190
PRE-ALGEBRA (9)	1,688	1,727	1,672	1,824	1,824	
ALGEBRA, ADVANCED (9)	920	1,040	1,112	1,131	1,150	909
MATH, OTHER (9)	347	334	370	331	390	404

While the total population of Nebraska 9th graders varies over the years (22,894 in 2014/15 to 24,433 in 2018/19), Table # shows that the majority of incoming freshman enroll in Beginning Algebra, Geometry, Pre-Algebra or Advanced Algebra. This means that most students start high school placed in Beginning Algebra, or on Path A. Path B (Geometry as Freshmen) represents the next largest group of students. The third largest group of students are Path C (Pre-Algebra as Freshmen). These three typical paths are confirmed in Table 3. In the sophomore year, most Nebraska students take Geometry (Path A, on track), second most take Advanced Algebra (Path B, slightly advanced), and the third largest course enrollment in 10th grade is Beginning Algebra (Path C, slightly behind).

Table 3

Nebraska 10th Grade Mathematic Course Enrollment Over Six Years

Course Name	Academic Year 20142015	20152016	20162017	20172018	20182019	20192020
GEOMETRY (10)	10,365	10,679	10,853	10,710	11,155	2,803
ALGEBRA, ADVANCED (10)	6,397	6,744	6,757	6,381	7,027	7,123
ALGEBRA, BEGINNING (10)	3,950	3,908	3,827	3,890	4,094	3,974
MATH, OTHER (10)	733	692	669	645	598	457
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (10)	477	522	617	669	737	697
PRE-ALGEBRA (10)	518	527	543	586	603	
MATHEMATICS, GENERAL (10)	190	188	198	122	250	358
TRIGONOMETRY (10)	183	188	228	209	196	
APPLIED MATHEMATICS III (10)	174	136	202	200	200	12
APPLIED MATHEMATICS II (10)	139	145	134	127	172	157
APPLIED MATHEMATICS I (10)	125	119	139	168	160	127
ADVANCED PLACEMENT STATISTICS (10)	89	78	87	70	71	100
BUSINESS MATH (10)	42	56	58	79	81	93
STATISTICS/PROBABILITY (10)	41	29	30	38	46	37
ARITHMETIC (10)		20	21	22	30	15
ADVANCED PLACEMENT CALCULUS BC (10)	23	18	21	16	16	
ADVANCED PLACEMENT CALCULUS AB (10)						12
CALCULUS (10)						12
MATHEMATICS-MIDDLE GRADES/JR HIGH II (10)						
FINITE/DISCRETE MATHEMATICS (10)						
COLLEGE TECHNICAL MATHEMATICS (10)						

Note: Enrollment counts less than 10 are not displayed.

Beyond these three typical paths, the divergence into advanced courses for tenth grade students such as Pre-Calculus, Calculus, Trigonometry, AP Statistics and AP Calculus AB or BC becomes evident. Likewise, so do the remedial pathways including Math Other, Pre-Algebra, Math General, Applied Math I, II, and III.

The three Paths A, B, and C are still present as the top three enrollments of 11th graders across the state as shown in Table #. Across all six years, the most enrollments are on Path A (on track) in Advanced Algebra. Path B (slightly above) remains the second most enrollment path, Precalculus or Trigonometry in the junior year and Path C (slightly below) remains the third most enrollment path, Geometry in 11th grade.

Table 4

Nebraska 11th Grade Mathematics Course Enrollment Over Six Years

	Academic Year					
Course Name	20142015	20152016	20162017	20172018	20182019	20192020
ALGEBRA, ADVANCED (11)	7,795	8,099	8,631	8,509	9,208	9,440
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (11)	4,297	4,462	4,728	4,403	4,768	5,093
GEOMETRY (11)	3,456	3,400	3,425	3,136	3,501	508
ALGEBRA, BEGINNING (11)	2,366	2,146	2,190	2,269	2,474	2,196
TRIGONOMETRY (11)	1,749	1,663	1,666	1,582	1,621	
MATH, OTHER (11)	1,287	1,436	1,375	1,245	1,331	1,201
STATISTICS/PROBABILITY (11)	486	401	404	335	650	697
MATHEMATICS, GENERAL (11)	339	280	291	220	256	340
ADVANCED PLACEMENT CALCULUS AB (11)	174	230	231	326	330	425
PRE-ALGEBRA (11)	286	283	293	277	394	
APPLIED MATHEMATICS I (11)	207	213	217	193	190	174
ADVANCED PLACEMENT STATISTICS (11)	128	172	193	181	222	171
BUSINESS MATH (11)	186	154	155	156	189	203
CALCULUS (11)	141	146	126	125	146	135
APPLIED MATHEMATICS III (11)	187	133	150	162	155	30
ADVANCED PLACEMENT CALCULUS BC (11)	89	81	95	132	166	
FINITE/DISCRETE MATHEMATICS (11)	54	48	35	54	44	15
COLLEGE TECHNICAL MATHEMATICS (11)				16	44	54
ARITHMETIC (11)	13	14	20	10	20	14
IB MATHEMATICS-HIGHER LEVEL (11)						37
IB MATHEMATICAL STUDIES-STANDARD LEVEL (11)						24
IB FURTHER MATHEMATICS-HIGHER LEVEL (11)						
MATHEMATICS-MIDDLE GRADES/JR HIGH II (11)						
MATHEMATICS-MIDDLE GRADES/JR HIGH III (11)						

Note: Enrollment counts less than 10 are not displayed.

Table 4 also shows the increased 11th grade enrollment in courses typically taken by freshman and sophomores such as Beginning Algebra, Geometry, and Math, Other. These enrollments suggest students may be taking courses in a lateral, or digressing path to satisfy graduation requirements. The course options become even more diverse for 12th graders (Table 5).

Table 5

Twelfth Grade Mathematics Course Enrollment Over Six Years

	Academic Year					
Course Name	20142015	20152016	20162017	20172018	20182019	20192020
ALGEBRA, ADVANCED (12)	2,963	3,131	3,685	3,646	3,902	3,939
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (12)	2,861	2,799	2,823	2,674	2,976	2,874
MATH, OTHER (12)	2,067	2,163	1,974	1,855	2,279	2,127
STATISTICS/PROBABILITY (12)	1,698	1,366	1,427	1,403	1,886	1,913
CALCULUS (12)	1,575	1,465	1,370	1,473	1,396	1,345
ADVANCED PLACEMENT STATISTICS (12)	856	1,034	1,113	1,196	1,396	1,522
ADVANCED PLACEMENT CALCULUS AB (12)	1,052	1,066	1,208	1,167	1,156	1,151
TRIGONOMETRY (12)	1,540	1,243	1,330	1,256	1,280	
ALGEBRA, BEGINNING (12)	925	948	943	1,053	1,403	1,243
GEOMETRY (12)	1,266	1,207	1,164	1,156	1,388	152
BUSINESS MATH (12)	578	589	564	563	502	634
APPLIED MATHEMATICS I (12)	302	290	334	410	410	396
FINITE/DISCRETE MATHEMATICS (12)	458	447	322	260	250	51
PRE-ALGEBRA (12)	304	334	320	280	366	
ADVANCED PLACEMENT CALCULUS BC (12)	290	306	312	307	324	
COLLEGE TECHNICAL MATHEMATICS (12)		45	23	156	277	354
APPLIED MATHEMATICS II (12)	116	114	115	102	137	142
APPLIED MATHEMATICS III (12)	41	60	88	90	65	
ARITHMETIC (12)		32	19	12	22	
IB FURTHER MATHEMATICS-HIGHER LEVEL (12)					19	13
IB MATHEMATICAL STUDIES-STANDARD LEVEL (12)					22	
IB MATHEMATICS-HIGHER LEVEL (12)						11
MATHEMATICS-MIDDLE GRADES/JR HIGH II (12)						
MATHEMATICS-MIDDLE GRADES/JR HIGH III (12)						

Note: Enrollment counts less than 10 are not displayed.

Nebraska requires a minimum of 21 credits for High School graduation. By twelfth grade students may have satisfied graduation requirements of 3 math courses and overall, the enrollment in math courses drops by about 11%. The diversity of course enrollments is apparent in 12th grade, students are more evenly dispersed across a greater number of courses. Path C students (slightly behind) are enrolled in Advanced Algebra. Students in Path A (on track) are enrolled in Precalculus and Trigonometry. Students in Path B (slightly advanced) are enrolled in Calculus and AP Calculus AB. A group not specifically noted earlier, very advanced, is seen here with enrollments in AP Statistics and AP Calculus BC. Not on the course list from the data is Differential Equations, also known as Calculus III. Another group not specifically noted earlier, very behind, are enrolled in Pre-Algebra, Applied Mathematics, Arithmetic, and other novice math courses.

Research Question 1 Result

What are the secondary mathematics course taking patterns of Nebraska students? The majority of Nebraska student course taking patterns are contained in one of three pathways:

Table 6

Path A-On Track Course Progression Enrollment Ranges from 2014 - 2020

9^{th} Grade Beginning Algebra	10^{th} Grade Geometry	11^{th} Grade Advanced Algebra	12^{th} Grade Precalculus and Trigonometry
N = [12,775 to 14,026]	*N* = [10,365 to 11,155]	*N* = [7,795 to 9,440]	*N* = [4,401 to NA]

Table 7

Path B-Slightly Advanced Course Progression Enrollment Ranges from 2014 - 2020

9^{th} Grade Geometry	10^{th} Grade Advanced Algebra	11^{th} Grade Precalculus and Trigonometry	12^{th} Grade Calculus and AP Calculus AB
N = [6,438 to 7,189]	*N* = [6,397 to 7,123]	*N* = [6,046 to NA]	*N* = [2,627 to 2,496]

Table 8

Path C-Slightly Behind Course Progression Enrollment Ranges from 2014 - 2020

9^{th} Grade Prealgebra	10^{th} Grade Beginning Algebra	11^{th} Grade Geometry	12^{th} Grade Advanced Algebra
N = [1,688 to NA]	*N* = [3,950 to 3,974]	*N* = [3,456 to NA]	*N* = [2,963 to 3,939]

The other diverse course pathways are varied and complex and not explored in this study. The data provided for this study had errors or gaps in the 2019-2020 course enrollments. For example, the reported enrollment in Geometry goes from 7,189 to 1,190 in 2018-29 to the 2019-2020 school year. These reason for the drastic drops in enrollment reported for Geometry is unknown. There are also courses with high enrollment trends such as 9th and 10th grade Pre-Algebra and all four years of Trigonometry courses that report no enrollment at all for the 2019-2020 school year. According to the 2014-2018 trend data provided there should be large groups of students reported for 2019-2020 courses, but no data was provided. This could be an error in the data or indication of unique reporting requirements that year. This is an area of needed future investigation.

This led the researcher to dig deeper and develop a better understanding of the attrition across the three pathways to graduation. In addition to increasing senior year Path C enrollments, the courses that increased enrollment numbers were Math (Other) and Statistics/Probability. Math (Other), Geometry and Beginning Algebra all of which would be considered remedial classes when taken during a student's senior year. This group of remedial classes account for an average of 20% of the senior year course enrollments. Seniors taking remedial courses are working to gain course credit required for graduation. In contrast, Statistics and AP Statistics courses also increase in enrollment senior year. These classes are not considered remedial for students during senior year but perhaps a lateral move made by "Path A: On Track" students or step up in content challenge for "Path C: Below Average" students. Some college admissions require four years of high school math and so Statistics and AP Statistics are options for students to take their senior year. Also, like other AP classes, AP Statistics can be used for college credit. This choice can provide financial benefits for students planning to attend college as they do not have to pay per credit hour for a college graduation course requirement. Once the three pathways were identified and understood, research turned to taking a deeper look at the data based on the characteristics of gender and race.

Analysis By Race

In the years of data included in this study, 2014-2020, students were reported to the state department of education in one of seven Race categories. These categories are seen in Tables 9 – 24 with each nuanced count or analysis.

Table 9

2014-2020 Nebraska Ninth Grade Mathematics Course Enrollments by Race Over Six Years

		Race						
Course Name	Academic Year	American Indian or Alaska Native	Asian	Black or African American	Hispanic	Native Hawaiian or Other Pacific Islander	Two Or More Races	White
ALGEBRA, BEGINNING (9)	20142015	155	191	905	2,468	22	381	8,653
Path A: On Track	20152016	173	251	911	2,465	22	407	8,582
	20162017	154	236	902	2,758	16	435	8,702
	20172018	164	228	902	2,670	17	453	8,397
	20182019	160	266	922	2,740	12	465	8,614
	20192020	165	312	976	2,883	30	573	9,087
GEOMETRY (9)	20142015	22	183	171	634		199	5,223
Path B: Advanced	20152016	30	189	189	643		194	5,216
	20162017	32	202	169	659		230	5,288
	20172018	27	232	204	717		229	5,133
	20182019	32	247	239	993		249	5,420
	20192020	14	25	21	79		30	1,019
PRE-ALGEBRA (9)	20142015	63	45	300	562		44	672
Path C: Below Average	20152016	59	49	307	676		46	589
	20162017	57	84	294	615		47	571
	20172018	50	43	328	711		49	641
	20182019	58	59	337	726		47	594

Note: Enrollment counts less than 10 are not displayed.

Ninth-grade data shows the majority of course enrollments in Beginning Algebra. This would place students on Path A or "On Track" to complete Precalculus or Trigonometry by senior year. The researcher noted that Pre-Algebra enrollment shows the number of White students dropping from over the six-year period. Hispanic student course enrollment also increased from 33% to 40% by 2018 and 2019. No 2019-2020 data was reported in the data source for Pre-Algebra. The percentage of African American and Asian students stayed the same in Pre-Algebra over time.

Table 10

2014-2020 Nebraska 10th Grade Mathematics Course Enrollments by Race Over Six Years

Course Name	Academic Year	American Indian or Alaska Native	Asian	Black or African American	Hispanic	Native Hawaiian or Other Pacific Islander	Two Or More Races	White
GEOMETRY (10)	20142015	128	173	659	1,735	12	332	7,326
	20152016	112	174	697	1,880	16	326	7,474
Path A: On Track	20162017	122	222	689	1,958	19	331	7,512
	20172018	104	226	657	2,093	20	328	7,282
	20182019	129	211	747	2,242	17	370	7,439
	20192020	43	30	93	377		87	2,172
ALGEBRA, ADVANCED (10)	20142015	25	204	173	619		204	5,166
	20152016	28	187	175	694		192	5,464
Path B: Advanced	20162017	41	192	188	712		193	5,426
	20172018	34	194	176	704		205	5,066
	20182019	26	244	209	818		251	5,471
	20192020	38	246	227	853	11	229	5,519
ALGEBRA, BEGINNING (10)	20142015	107	89	439	1,047		141	2,118
	20152016	82	85	510	1,114	11	113	1,993
Path C: Below Average	20162017	93	92	498	1,129		142	1,869
	20172018	72	104	446	1,179		144	1,941
	20182019	71	79	521	1,269		159	1,990
	20192020	87	104	481	1,213		146	1,936

Note: Enrollment counts less than 10 are not displayed.

The researcher noted that white student course enrollment in Geometry grew from 7,326 to 7,439, which is an increase of 113 enrollments, from the 2014/15 school year to the 2018/19 school year. Over the same five-year time span Hispanic student course enrollment grew in Geometry from 1,735 to 2,242, or by 507 enrollments, which is a noticeable difference compared to the increase in enrollments for white students. The 2019-2020 data was not used due to abnormally low numbers that did not follow previous annual trends. Tenth grade data reaffirms that most of the students, regardless of race are on Path A, Path B or Path C.

Table 11

2014-2020 Nebraska 11th Grade Mathematics Course Enrollments by Race Over Six Years

Course Name	Academic Year	American Indian or Alaska Native	Asian	Black or African American	Hispanic	Native Hawaiian or Other Pacific Islander	Two Or More Races	White
ALGEBRA, ADVANCED (11)	20142015	79	151	516	1,243	10	214	5,582
Path A: On Track	20152016	102	139	499	1,368		261	5,723
	20162017	93	144	560	1,472	10	264	6,088
	20172018	80	182	517	1,531	12	234	5,953
	20182019	86	204	556	1,770	14	287	6,291
	20192020	111	195	653	1,794	16	307	6,364
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (11)	20142015	19	128	127	352		127	3,541
Path B: Advanced	20152016	13	167	132	431		152	3,563
	20162017	10	171	122	532		135	3,755
	20172018	16	160	133	482		133	3,476
	20182019		176	137	501		168	3,777
	20192020	16	216	149	598		187	3,922
GEOMETRY (11)	20142015	63	69	369	826	11	126	1,992
Path C: Below Average	20152016	86	76	378	886		118	1,848
	20162017	70	70	425	936	11	109	1,804
	20172018	66	79	396	830		105	1,655
	20182019	55	98	433	1,000		141	1,768
	20192020	22		21	102		15	343
ALGEBRA, BEGINNING (11)	20142015	43	57	240	616		59	1,344
	20152016	39	56	230	554		83	1,177
	20162017	36	61	266	654		77	1,094
	20172018	51	70	276	701		65	1,099
	20182019	42	57	336	851		97	1,086
	20192020	42	39	282	659		89	1,076
TRIGONOMETRY (11)	20142015		16	20	140		26	1,538
Path B: Advanced	20152016	12	20	10	131		26	1,461
	20162017	11	21	17	162		23	1,430
	20172018	15	11	17	131		22	1,386
	20182019		12		132		23	1,440

Note: Enrollment counts less than 10 are not displayed.

At 11th grade enrollment in Path A (Advanced Algebra) shows growth across all races. Precalculus enrollment also went up for White, Hispanic, African American, Asian, and Native Hawaiian students. Enrollment for Path B (Precalculus) decreases for American Indian and Two or More Races, but the difference may be attributed to the low number of students represented in the state. Path C (Geometry) went from 1,992 to 1,768 showing a declined enrollment of 224 over a five-year period. Native Hawaiian enrollment also decreased but the researcher again noted that the small population of students may be difficult to use when drawing trend conclusions for this population of students. Geometry enrollment grew in all other race groups.

Table 12

2014-2020 Nebraska 12th Grade Mathematics Course Enrollments by Race Over Six Years

Course Name	Academic Year	American Indian or Alaska Native	Asian	Black or African American	Hispanic	Native Hawaiian or Other Pacific Islander	Two Or More Races	White
		Race						
ALGEBRA, ADVANCED (12)	20142015	49	92	337	655		113	1,710
	20152016	41	93	364	665		114	1,848
Path C: Below Average	20162017	54	99	391	826		138	2,169
	20172018	48	92	391	775		130	2,204
	20182019	45	116	462	840		168	2,262
	20192020	36	139	431	889		162	2,273
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (12)	20142015	12	90	165	389		101	2,100
	20152016	22	89	149	395		65	2,077
Path A: On Track	20162017	22	84	148	392		99	2,076
	20172018	26	87	177	433		86	1,864
	20182019	22	110	166	486		95	2,093
	20192020	26	113	168	453		97	2,011
MATH, OTHER (12)	20142015	21	50	82	336		33	1,544
	20152016	15	47	92	375		41	1,591
	20162017	28	45	107	401		38	1,352
	20172018	46	51	56	352		38	1,312
	20182019	47	51	86	451		42	1,601
	20192020	26	54	53	491		39	1,463
STATISTICS/PROBABILITY (12)	20142015	13	35	79	246		50	1,272
	20152016		25	74	212		41	1,006
	20162017	10	31	71	244		56	1,012
	20172018	17	24	64	199		30	1,068
	20182019	12	38	82	339		56	1,359
	20192020	14	36	87	384		42	1,346
CALCULUS (12)	20142015		34	10	88		21	1,416
	20152016		41	16	68		24	1,310
Path B: Advanced	20162017		38	10	99		22	1,197
	20172018		33	15	115		21	1,282
	20182019		41	9	97		19	1,225
	20192020		34	10	109		19	1,171
ADVANCED PLACEMENT STATISTICS (12)	20142015		37	41	45		33	697
	20152016		45	39	79		47	821
	20162017		59	45	70		35	902
	20172018		59	44	106		32	954
	20182019		69	59	143		52	1,067
	20192020		84	51	132		50	1,205
ADVANCED PLACEMENT CALCULUS AB (12)	20142015		49	33	55		32	877
	20152016		48	32	80		36	863
Path B: Advanced	20162017		66	27	101		35	973
	20172018		70	18	148		38	891
	20182019		62	33	122		25	908
	20192020		66	32	112		41	897
TRIGONOMETRY (12)	20142015	13	20	29	182		30	1,262
	20152016	18	13	30	141		26	1,015
Path A: On Track	20162017	20	21	35	164		32	1,056
	20172018		14	34	175		29	994
	20182019		16	40	225		32	957
ALGEBRA, BEGINNING (12)	20142015	17	44	139	265		36	423
	20152016	15	39	136	316		34	405
	20162017	14	57	158	327		36	348
	20172018	16	46	173	387		48	383
	20182019	47	42	268	518		48	476
	20192020	25	34	223	484		50	422
GEOMETRY (12)	20142015	31	62	166	387		48	568
	20152016	29	51	151	388		33	551
	20162017	27	48	137	358		58	532
	20172018	25	55	161	386		43	484
	20182019	33	63	199	455		53	583
	20192020			17	46			74

Note: Enrollment counts less than 10 are not displayed.

In Twelfth Grade we can again see that student are less concentrated into just a few courses. There is a more even distribution across a larger number of courses. Enrollment in Path A (Precalculus/Trigonometry), Path B (Calculus/AP Calculus AB or BC) and Path C (Advanced Algebra) courses now represents 50% of the total course enrollments at 12th Grade across all six years. With inconsistent 2019-2020 data provided for some courses included in the pathways the researcher also calculated the Path A, B and C percentage of 12th Grade enrollment over five years from 2014-2019. A similar conclusion was reached with 51% of courses matching with a studied path's final senior year destination.

A further look at the data using χ^2 allows us to analyze if the 10th, 11th and 12th grade course enrollment truly does or does not follow the 9th grade distribution. While the original conclusions from table #5 was that patterns persisted, it is in fact very different. Significance is noted in yellow. Also, 12th grade Precalculus/Trigonometry data was not available.

Table 13

Path A-On Track Pathway χ^2 Analysis by Race, Cohort 2018

Cohort 2018	9th		10th		11th		12th	
Actual	Beg Alg		Geo		Adv. Alg		PC/Trig	
White	8647	68.67%	7472	70.84%	6082	71%	2858	75.55%
Hispanic	2468	19.60%	1879	17.81%	1472	17%	608	16.07%
African American	905	7.19%	697	6.61%	560	7%	101	2.67%
Two or More Races	381	3.03%	326	3.09%	264	3%	115	3.04%
Asian	191	1.52%	174	1.65%	144	2%	101	2.67%
Totals	12592	100.00%	10548	100.00%	8522	98%	3783	100.00%
Expected								
W			7243.37		5852.107211		2597.80821	
H			2067.38		1670.290343		741.458386	
AA			758.10		612.4849111		271.888104	
TM			319.15		257.8527637		114.463389	
Asian			160.00		129.2647713		57.3819091	
			3.561E-06		7.32284E-08		3.8472E-40	

Table 14

Path A-On Track Pathway χ^2 Analysis by Race, Cohort 2019

Cohort 2019	9th		10th		11th		12th	
Actual	Beg Alg		Geo		Adv. Alg		PC/Trig	
White	8567	68.00%	7505	70.11%	5947	71%	3048	72.30%
Hispanic	2463	19.55%	1957	18.28%	1531	18%	710	16.84%
African American	911	7.23%	689	6.44%	517	6%	206	4.89%
Two or More Races	407	3.23%	331	3.09%	234	3%	127	3.01%
Asian	251	1.99%	222	2.07%	182	2%	125	2.96%
Totals	12599		10704.00	100.00%	8411	98%	4216	100.00%
Expected								
W			7278.45		5719.26637		2866.77292	
H			2092.54		1644.280737		824.193031	
AA			773.98		608.1769188		304.847686	
TM			345.78		271.7102151		136.194301	
Asian			213.25		167.5657592		83.9920629	
			2.94776E-05		1.78547E-07		1.7658E-16	

Table 15

Path A-On Track Pathway χ^2 Analysis by Race, Cohort 2020

Cohort 2020	9th		10th		11th		12th	
Actual	Beg Alg		Geo		Adv. Alg		PC/Trig	
White	8683	66.74%	7271	68.76%	6289	69%		#DIV/0!
Hispanic	2755	21.17%	2093	19.79%	1770	19%		#DIV/0!
African American	902	6.93%	657	6.21%	556	6%		#DIV/0!
Two or More Races	435	3.34%	328	3.10%	287	3%		#DIV/0!
Asian	236	1.81%	226	2.14%	204	2%		
Totals	13011		10575		9106	98%	0	
							no trig data	
Expected								
W			7057.31		6076.97		0	
H			2239.19		1928.14		0	
AA			733.12		631.28		0	
TM			353.56		304.44		0	
As			191.8146		165.17			
p			2.04486E-06		5.55895E-08		#DIV/0!	

The distribution of enrollment by race in 9th grade is significantly different across grades for all three analyzed cohorts of students. In plain language, the distribution in 9th grade changes as the students complete high school for those who start in Path A, On Track.

The researcher next completed the same χ^2 calculation for Path B, Advanced Pathway.

Table 16

Path B-Advanced Pathway χ^2 Analysis by Race, Cohort 2018

Cohort 2018	9th		10th		11th		12th	
Actual	Geo		Adv Alg		PreCal/Trig		Calc/AP Calc AB/BC	
White	5223	81.38%	5463	81.40%	5185	81.42%	2415	82.20%
Hispanic	634	9.88%	694	10.34%	694	10.90%	277	9.43%
African American	171	2.66%	175	2.61%	139	2.18%	42	1.43%
Two or More Race	199	3.10%	192	2.86%	158	2.48%	68	2.31%
Asian	191	2.98%	187	2.79%	192	3.02%	136	4.63%
Totals	6418		6711	100.00%	6368	96.98%	2938	
Expected								
W			5461.44		5182.309754		2390.958866	
H			662.94		629.0607666		290.2293549	
AA			178.81		169.6678093		78.27952633	
TM			208.08		197.4496728		91.09722655	
As			199.72		189.5119975		87.43502649	
p			0.464359		0.000463717		2.85279E-10	

Table 17

Path B-Advanced Pathway χ^2 Analysis by Race, Cohort 2019

Cohort 2019	9th		10th		11th		12th	
Actual	Geo		Adv Alg		PreCal/Trig		Calc/AP Calc AB/BC	
White	5216	81.11%	5425	80.85%	4862	82%	2384	83.21%
Hispanic	643	10.00%	712	10.61%	613	10%	243	8.48%
African American	189	2.94%	188	2.80%	150	3%	48	1.68%
Two or More Race	194	3.02%	193	2.88%	155	3%	52	1.82%
Asian	189	2.94%	192	2.86%	171	3%	138	4.82%
Totals	6431	100.00%	6710	100.00%	5951	97%	2865	100.00%
Expected								
W			5442.29		4826.685741		2323.719484	
H			670.90		595.0074638		286.4554502	
AA			197.20		174.8933292		84.19919142	
TM			202.42		179.5201368		86.42668325	
As			197.20		174.8933292		84.19919142	
p			0.466177		0.099920671		9.41649E-15	

Table 18

Path B-Advanced Pathway χ^2 Analysis by Race, Cohort 2020

Cohort 2020	9th		10th		11th		12th
Actual	Geo		Adv Alg		PreCal/Trig		Calc/AP Calc AB/BC
White	5288		5066	79.84%	5217	82%	
Hispanic	659	80.76%	704	11.10%	633	10%	
African American	169	10.06%	176	2.77%	146	2%	
Two or More Race:	230	2.58%	205	3.23%	191	3%	
Asian	202	3.51%	194	3.06%	188		
Totals	6548	3.08%	6345		6375	97%	0
Expected							
W			5124.06		5148.289554		0
H			638.57		641.5890348		0
AA			163.76		164.5349725		0
TM			222.87		223.9233354		0
As			195.74		223.9233354		
p			0.045322		0.008230949		#DIV/0!

In Path B, Advanced Pathway, the ninth-grade enrollment distribution reflects as expected moving into 10th grade for two cohorts, along with one 11th grade group in 2019. Students who start ahead in math seem to stay ahead through sophomore and in the 2019 cohort, junior year. Senior year is significantly different. NDE data was incomplete for the 2020 school year with missing enrollments for courses on path B.

Next, the researcher next completed the same χ^2 calculation for Path C, Below Average Pathway for each of the three cohorts.

Table 19

Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2018

Cohort 2018	9th		10th		11th		12th	
Actual	PreAlg		Beg. Alg		Geo		Adv. Ag	
White	671	41.39%	1986	52.21%	1800	53.89%	2170	61.39%
Hispanic	561	34.61%	1110	29.18%	936	28.02%	762	21.56%
African American	300	18.51%	510	13.41%	425	12.72%	387	10.95%
Two or More Races	44	2.71%	113	2.97%	109	3.26%	125	3.54%
Asian	45	2.78%	85	2.23%	70	2.10%	91	2.57%
Totals	1621	100.00%	3804	100.00%	3340	98%	3535	100.00%
Expected								
W			1574.64		1382.566		1463.285	
H			1316.50		1155.916		1223.402	
AA			704.01		618.137		654.2258	
TM			103.25		90.66009		95.95312	
Asian			105.60		92.72054		98.13387	
p			8.89E-42		3.21E-50		7.5E-136	

Table 20

Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2019

Cohort 2019	9th		10th		11th		12th	
Actual	PreAlg		Beg. Alg		Geo		Adv. Ag	
White	587	35.26%	1863	50.07%	1649	54%	2220	58.96%
Hispanic	675	40.54%	1127	30.29%	830	27%	818	21.73%
African American	308	18.50%	498	13.38%	395	13%	457	12.14%
Two or More Races	46	2.76%	141	3.79%	105	3%	157	4.17%
Asian	49	2.94%	92	2.47%	79	3%	113	3.00%
Totals	1665	100.00%	3721	100.00%	3058	97%	3765	100.00%
Expected								
W			1311.85		1078.106		1327.36	
H			1508.51		1239.73		1526.351	
AA			688.33		565.6841		696.4685	
TM			102.80		84.48529		104.018	
Asian			109.51		89.9952		110.8018	
p			8.89E-85		6.1E-106		1.7E-223	

Table 21

Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2020

Cohort 2020	9th		10th		11th		12th	
Actual	PreAlg		Beg. Alg		Geo		Adv. Ag	
White	569	31.11%	1927	50.76%	1762	51%	2248	58.44%
Hispanic	659	36.03%	1176	30.98%	1000	29%	876	22.77%
African American	169	9.24%	446	11.75%	432	13%	429	11.15%
Two or More Races	230	12.58%	143	3.77%	141	4%	158	4.11%
Asian	202	11.04%	104	2.74%	98	3%	136	3.54%
Totals	1829	100.00%	3796	100.00%	3433	97%	3847	100.00%
Expected								
W			1180.93		1068.003		1196.798	
H			1367.72		1236.931		1386.098	
AA			350.75		317.21		355.4636	
TM			477.35		431.7059		483.7671	
Asian			419.24		379.1504		424.8737	
p			3.7E-214		1.2E-202		0	

Path C enrollments are different than Paths A and B. Path C expected distribution based on 9th grade course enrollments does not persist at any grade level in any cohort. Enrollments grow in Path C unlike in either of other pathways suggesting that students leave Path A or B and join courses in Path C. The review of the χ^2 prompted the researcher to examine the overall starting enrollment in pathways at 9th grade with the 12th grade enrollment numbers, again by race. The following tables show the starting course enrollments compared to the 12th grade enrollments on the same path, the final column shows the difference.

Table 22

"On Track" Path A Completion Comparison, Combined 2018-2019 Cohorts

Pathway A-On Track			
	9th Grade Beginning Algebra	12th Grade PC/Trig	Difference
White	17214	5906	-11308
Hispanic	4931	1318	-3613
African American	1816	307	-1509
Two or More Races	788	242	-546
Asian	442	226	-216
	25191	7999	-17192

On Track, Path A, completion averages showed Asian students appear to drop by approximately half of the starting enrollments. White, Two or More Races and Hispanic completion percentages hovered around the 25-33% range while African American students who start with 1816 course enrollments end senior year with 307 course enrollments.

Table 23

"Slightly Advanced" Path B Completion Comparison, Combined 2018-2019 Cohorts

Pathway B-Slightly Advanced			
	9th Grade Geometry	Calc/AP Calc AB/BC	
White	10439	4799	-5640
Hispanic	1277	520	-757
African American	360	90	-270
Two or More Races	393	120	-273
Asian	380	274	-106
	12849	5803	-7046

Slightly Advanced, or Path B, enrollment completion numbers drop less than they did in Path A. This again reaffirms the idea that students who start ahead may tend to stay ahead. Asian enrollments again seem to drop less than other races. Although the total numbers differ greatly the White and Hispanic enrollment averages seem to drop at a similar distribution rate. Completion rates for African American students on path B are again appeared to be much lower than other races.

Table 24

"Slightly Below" Path C Completion Comparison, Combined 2018-2020 Cohorts

Pathway C- Below Average			
	9th Grade Pre Algebra	12th Adv. Algebra	
White	1258	6560	5302
Hispanic	1236	1580	344
African American	608	844	236
Two or More Races	90	282	192
Asian	94	204	110
	3286	9470	6184

Unlike the decrease in students reflected by the negative numbers on Path A and B, Path C enrollments show growth across all races. This increase in enrollment suggests that as students exit Path and B, they enter courses in Path C. In this group, White students showed the highest percentage of increased enrollments, followed by students of Two or More Races and Asian students. Although the African American completion averages of Path A and B were the lowest, African American growth in Path C is also lower than other races. The researcher found this particularly interesting and recommends this as an area for continued study.

Research Question 2 (Race) Results

> Do the secondary mathematics course taking patterns of Nebraska students vary by race?

The short answer is yes. Tables 9 – 24 demonstrate this study's analysis of Nebraska high school students' math course taking patterns. Using the three pathways identified from Research Question 1, Path A, B, and C, the researcher reviewed these three paths disaggregating by race.

Chi-square tests were used to determine if patterns of course taking established in 9th grade persisted in high school. In "Path A: On Track" a statistically significant change was identified in all three cohorts at each grade level. This means there was a significant difference between the number of students expected to enroll in the courses and the actual number who enrolled for each course at each grade. When comparing the 2018 and 2019 ninth grade course enrollments for Beginning Algebra with the end of pathway A enrollment in Precalculus/Trigonometry the completion rates were as follows: White students: 35%, Hispanic students: 27%, African American students: 17%, Students of Two or More Races: 31% and Asian students: 51%. On Path A it's important to note that all groups showed attrition across all course and grades. It is also noteworthy that completion rates could not be calculated for the 2020 cohort as there were no Trigonometry enrollments included in the data.

The “Path B: Slightly Advanced” pathway yielded somewhat varied results showing a significant difference in enrollments in 11th and 12th grade for the 2018 cohort. Another significant difference from expected enrollment occurred in the 2019 cohort at 12th grade. Once again, the 2020 data was impacted by unreported numbers for Calculus BC so the 12th grade courses could not be calculated. A significant difference was observed in the 2020 cohort at 10th and 11th grade. To summarize these findings the greatest, drop off in course enrollments was observed from 11th grade Precalculus/Trigonometry to 12th grade Calculus/AP Calculus AB or BC. These changes from one year to the next were dramatic and interesting in Path B. The example is best explained using the Hispanic on track enrollment data showing 100% of students moving from 10th grade Advanced Algebra to 11th grade Precalculus/Trigonometry but enrollment drops from 694 to 277. 12th grade enrollments for Calculus/Calculus AB or BC yields a 44% pathway completion rate. Students of two or more races completed pathway B with an average completion rate of 31% followed by African American enrollments at 25%. Asian student enrollments in Path B showed an impressive pathway completion rate of 72% dropping only 55 enrollments from freshman year to senior year. This data points to something important happening between junior and senior year. Possible scenarios that may explain this exodus from Path B courses could include completed graduation course requirements or the researcher believes that students are selecting a different course than the senior calculus options outside of this pathway. In all three cohort’s enrollments in Statistics and AP Statistics jumps dramatically.

With pathway A and B attrition across both the 2018 and 2019 cohorts one might anticipate that the "Path C: Below Average" pathway yielded very different results. Rather than decreasing enrollments over time all 2018 and 2019 cohort enrollments for each race dramatically. Courses grew on average in pathway C as follows: White students 250%, Hispanic students 30%, African American students 77%, Students of Two or more races 131% and Asian students 67%. In 2020 students of two or more races and Asian students showed 31% and 33% decreases in enrollment respectively but this data did not align with the other trend data from Cohorts 2018 and 2019 where enrollments grew for both races.

Analysis By Gender

After a review of course enrollment over time by race the researcher compared enrollment over the same time period, 2014-2020, by gender. The following tables illustrate the 9th-12th grade course enrollment by year disaggregated by gender.

Table 25

Nebraska 9th Grade Mathematics Course Enrollment by Gender Over Six Years

	Academic Year / Gender											
	20142015		20152016		20162017		20172018		20182019		20192020	
Course Name	F	M	F	M	F	M	F	M	F	M	F	M
ALGEBRA, BEGINNING (9)	6,297	6,478	6,325	6,486	6,523	6,680	6,327	6,504	6,409	6,770	6,861	7,165
GEOMETRY (9)	3,336	3,102	3,376	3,090	3,408	3,174	3,311	3,236	3,758	3,431	621	569
PRE-ALGEBRA (9)	739	949	727	1,000	709	963	754	1,070	750	1,074		
ALGEBRA, ADVANCED (9)	404	516	521	519	566	546	542	589	527	623	454	455
MATHEMATICS, GENERAL (9)	153	195	145	189	132	188	54	96	109	159	105	145
MATH, OTHER (9)	151	196	125	209	161	209	178	153	161	229	191	213
APPLIED MATHEMATICS I (9)	87	147	80	138	67	122	88	134	112	162	118	154
APPLIED MATHEMATICS II (9)	17	17	14	14	22	26	18	27		17	21	17
ARITHMETIC (9)	15	17	20	25	12	22	17	30		33	10	20
BUSINESS MATH (9)		14		14		11	12	13		11		13
TRIGONOMETRY (9)		16	13	10		16	10	14				
MATHEMATICS-MIDDLE GRADES/JR HIGH II (9)												
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (9)				15		19		20	11	16	10	20
MATHEMATICS-MIDDLE GRADES/JR HIGH I (9)												
APPLIED MATHEMATICS III (9)						13	11					
ADVANCED PLACEMENT STATISTICS (9)												
STATISTICS/PROBABILITY (9)												
CALCULUS (9)												
ADVANCED PLACEMENT CALCULUS BC (9)												
ADVANCED PLACEMENT CALCULUS AB (9)												

Note: Enrollment counts less than 10 are not displayed.

Most Ninth-Grade students in Nebraska start on Path A (on track) or Path B (slightly advanced). There are fewer choices available to ninth grade student, as they progress through high school more options are available to fulfill math credits required for graduation. This table shows more males enrollments in Beginning Algebra and Pre-Algebra than females. It also shows a greater number of female enrollments in Geometry than male students.

Table 26

Nebraska 10th Grade Mathematics Course Enrollment by Gender Over Six Years

	Academic Year / Gender											
	20142015		20152016		20162017		20172018		20182019		20192020	
Course Name	F	M	F	M	F	M	F	M	F	M	F	M
GEOMETRY (10)	5,217	5,148	5,348	5,331	5,524	5,329	5,433	5,277	5,584	5,571	1,419	1,384
ALGEBRA, ADVANCED (10)	3,313	3,084	3,554	3,190	3,595	3,162	3,365	3,016	3,590	3,437	3,782	3,341
ALGEBRA, BEGINNING (10)	1,709	2,241	1,718	2,190	1,603	2,224	1,675	2,215	1,681	2,413	1,673	2,301
MATH, OTHER (10)	313	420	319	373	297	372	306	339	284	314	199	258
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (10)	228	249	225	297	305	312	344	325	353	384	300	397
PRE-ALGEBRA (10)	197	321	190	337	201	342	201	385	215	388		
TRIGONOMETRY (10)	94	89	94	94	108	120	110	99	105	91		
APPLIED MATHEMATICS III (10)	84	90	63	73	87	115	89	111	90	110		10
MATHEMATICS, GENERAL (10)	71	119	81	107	81	117	40	82	109	141	151	207
APPLIED MATHEMATICS II (10)	63	76	50	95	45	89	42	85	65	107	66	91
APPLIED MATHEMATICS I (10)	45	80	43	76	52	87	75	93	64	96	55	72
ADVANCED PLACEMENT STATISTICS (10)	33	56	30	48	37	50	30	40	25	46	41	59
STATISTICS/PROBABILITY (10)	23	18	10	19	17	13	18	20	33	13	19	18
BUSINESS MATH (10)	23	19	26	30	23	35	30	49	38	43	44	49
ADVANCED PLACEMENT CALCULUS BC (10)		19		12		16		14		10		
ADVANCED PLACEMENT CALCULUS AB (10)												
FINITE/DISCRETE MATHEMATICS (10)												
CALCULUS (10)												
ARITHMETIC (10)								16	10	20		12
MATHEMATICS-MIDDLE GRADES/JR HIGH II (10)												
MATHEMATICS-MIDDLE GRADES/JR HIGH I (10)												
COLLEGE TECHNICAL MATHEMATICS (10)												

Note: Enrollment counts less than 10 are not displayed.

The reader should note that again the incomplete data for 2019-2020 school year is evident in some courses and the numbers that are reported do not align with previous trend data. The course listed highest with most enrollments is Geometry, which is considered "on-track" in 10th grade. Enrollment in Advanced Algebra at tenth grade follows the "slightly advanced" Path B group of students. Students in Beginning Algebra represent the "slightly below grade level" group. These three courses and pathways represent 87%-89% of tenth grade students. In tenth grade Pre-Algebra, Math or Other, Applied Math and Mathematics General are considered remedial courses. Precalculus, Trigonometry, AP Statistics and Statistics and Probability are all considered advanced courses.

Table 27

Nebraska 11th Grade Mathematics Course Enrollment by Gender Over Six Years

	Academic Year / Gender											
	20142015		20152016		20162017		20172018		20182019		20192020	
Course Name	F	M	F	M	F	M	F	M	F	M	F	M
ALGEBRA, ADVANCED (11)	3,953	3,842	4,080	4,019	4,345	4,286	4,332	4,177	4,679	4,529	4,741	4,699
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (11)	2,288	2,009	2,314	2,148	2,497	2,231	2,379	2,024	2,505	2,263	2,616	2,477
GEOMETRY (11)	1,559	1,897	1,514	1,886	1,571	1,854	1,393	1,743	1,592	1,909	216	292
ALGEBRA, BEGINNING (11)	1,056	1,310	914	1,232	978	1,212	981	1,288	1,019	1,455	963	1,233
TRIGONOMETRY (11)	929	820	883	780	869	797	811	771	864	757		
MATH, OTHER (11)	581	706	671	765	572	803	550	695	645	686	544	657
STATISTICS/PROBABILITY (11)	232	254	195	206	211	193	164	171	356	294	342	355
MATHEMATICS, GENERAL (11)	143	196	115	165	120	171	89	131	112	144	145	195
ADVANCED PLACEMENT CALCULUS AB (11)	77	97	115	115	110	121	164	162	171	159	198	227
PRE-ALGEBRA (11)	105	181	111	172	120	173	115	162	136	258		
APPLIED MATHEMATICS I (11)	78	129	77	136	85	132	66	127	70	120	67	107
ADVANCED PLACEMENT STATISTICS (11)	65	63	76	96	81	112	90	91	105	117	82	89
BUSINESS MATH (11)	83	103	71	83	64	91	68	88	92	97	84	119
CALCULUS (11)	59	82	69	77	54	72	62	63	70	76	79	56
APPLIED MATHEMATICS III (11)	77	110	52	81	54	96	61	101	68	87	13	17
ADVANCED PLACEMENT CALCULUS BC (11)	32	57	32	49	36	59	56	76	80	86		
FINITE/DISCRETE MATHEMATICS (11)	24	30	27	21	17	18	21	33	22	22		10
COLLEGE TECHNICAL MATHEMATICS (11)								16	16	28	21	33
ARITHMETIC (11)										16		
IB MATHEMATICS-HIGHER LEVEL (11)											21	
IB MATHEMATICAL STUDIES-STANDARD LEVEL (11)											18	
IB FURTHER MATHEMATICS-HIGHER LEVEL (11)												
MATHEMATICS-MIDDLE GRADES/JR HIGH II (11)												
MATHEMATICS-MIDDLE GRADES/JR HIGH III (11)												

Note: Enrollment counts less than 10 are not displayed.

Table 28

Nebraska 12th Grade Mathematics Course Enrollment by Gender Over Six Years

	Academic Year / Gender											
	20142015		20152016		20162017		20172018		20182019		20192020	
Course Name	F	M	F	M	F	M	F	M	F	M	F	M
ALGEBRA, ADVANCED (12)	1,445	1,518	1,541	1,590	1,820	1,865	1,826	1,820	1,923	1,979	1,919	2,020
PRE CALCULUS (INTRODUCTION TO ANALYSIS) (12)	1,530	1,331	1,513	1,286	1,474	1,349	1,423	1,251	1,592	1,384	1,535	1,339
MATH, OTHER (12)	1,094	973	1,062	1,101	981	993	938	917	1,149	1,130	1,085	1,042
STATISTICS/PROBABILITY (12)	904	794	723	643	782	645	736	667	1,025	861	1,042	871
CALCULUS (12)	763	812	733	732	677	693	739	734	697	699	679	666
ADVANCED PLACEMENT STATISTICS (12)	482	374	594	440	605	508	649	547	781	615	894	628
ADVANCED PLACEMENT CALCULUS AB (12)	475	577	516	550	584	624	570	597	602	554	570	581
TRIGONOMETRY (12)	779	761	653	590	659	671	660	596	688	592		
ALGEBRA, BEGINNING (12)	363	562	378	570	389	554	442	611	564	839	463	780
GEOMETRY (12)	563	703	530	677	478	686	512	644	590	798	62	90
BUSINESS MATH (12)	232	346	247	342	239	325	234	329	209	293	257	377
APPLIED MATHEMATICS I (12)	116	186	96	194	131	203	143	267	153	257	149	247
FINITE/DISCRETE MATHEMATICS (12)	236	222	205	242	145	177	126	134	126	124	25	26
PRE-ALGEBRA (12)	112	192	128	206	118	202	131	149	145	221		
ADVANCED PLACEMENT CALCULUS BC (12)	123	167	129	177	143	169	133	174	144	180		
COLLEGE TECHNICAL MATHEMATICS (12)			23	22		14	52	104	104	173	149	205
APPLIED MATHEMATICS II (12)	39	77	48	66	35	80	43	59	49	88	57	85
APPLIED MATHEMATICS III (12)	19	22	32	28	36	52	25	65	21	44		
ARITHMETIC (12)			16	16	13					14		
IB FURTHER MATHEMATICS-HIGHER LEVEL (12)									14			
IB MATHEMATICAL STUDIES-STANDARD LEVEL (12)									15			
IB MATHEMATICS-HIGHER LEVEL (12)												
MATHEMATICS-MIDDLE GRADES/JR HIGH II (12)												
MATHEMATICS-MIDDLE GRADES/JR HIGH III (12)												

Note: Enrollment counts less than 10 are not displayed.

In 12th grade the number of enrollments drops slightly as some students have completed graduation requirements and may opt out of math courses senior year. Students still taking math courses tend to be either students who need additional support or those who love math and enjoy math classes. These trends can be seen by the number of students enrolled in Advanced Algebra, Precalculus, Statistics and Probability, Calculus, AP courses and Trigonometry. Remedial course enrollment drops drastically for students in 12th grade.

At first glance the raw gender enrollment numbers above appear equal in distribution. Like with race the researcher needed to analyze this data more closely using χ^2 by cohort. The following tables display the course enrollment numbers for students across the state of Nebraska starting with Beginning Algebra as a ninth grader. These tables follow three Cohort groups. They are the graduating classes of 2018, 2019 and 2020. These enrollment statistics were used to establish expected proportions for course progressions and determine if there was a significant difference between female and male students per course.

Table 29

Path A-On Track Pathway χ^2 Analysis by Gender, Cohort 2018

Beginning Algebra to Precalculus/Trigonometry Pathway Course Enrollment For Graduating Class of 2018 Nebraska Students

	9th Grade Beg. Algebra		10th Grade Geometry	11th Grade Advanced Alg.	12th Grade Precalculus/Trig
M	6473	50.70%	5382	4282	1847
F	6294	49.30%	5348	4343	2083
			$p = 0.26$	$p = 0.05$	$p = 3.42E\text{-}06$

The researcher noted there is not a significant difference between the number of students who advanced from ninth grade Beginning Algebra to Geometry in tenth grade. However, a statistically significant difference was found between the number of males and females enrolled in 11th Grade Advanced Algebra and 12th Grade Precalculus/Trigonometry. This data shows more females enrolled in the more challenging courses in 11th and 12th grade years.

Table 30

Path A-On Track Pathway χ^2 Analysis by Gender, Cohort 2019

Beginning Algebra to Precalculus/Trigonometry Pathway Course Enrollment For Graduating Class of 2019 Nebraska Students

	9th Grade Beg. Algebra		10th Grade Geometry	11th Grade Adv. Algebra	12th Grade Precalculus/Trig
M	6472	50.59%	5321	4173	1974
F	6320	49.41%	5542	4330	2278
			$p = 0.001438$	$p = 0.005134$	$p = 5.41E\text{-}08$

The 2019 Cohort data shows that more females enrolled in Geometry, Advanced Algebra and Precalculus/Trig courses than males. The difference between the groups was significant at all three grade levels.

Table 31

Path A-On Track Pathway χ^2 Analysis by Gender, Cohort 2020

Beginning Algebra to Precalculus/Trigonometry Pathway Course Enrollment
For
Graduating Class of 2020 Nebraska Students

	9th Grade Beg. Algebra		10th Grade Geometry	11th Grade Adv. Algebra	12th Grade Precalculus/Trig
M	6665	50.58%	5266	4528	
F	6512	49.42%	5433	4678	
			$p = 0.004867$	$p = 0.007415$	

The 2020 data shows similar findings to 2019 in that there is a significant difference between the number of male and female course enrollments in both Geometry and Advanced Algebra. The reader will again see that no data was reported for the number of students enrolled in Trigonometry for the 2020 twelfth grade students. Therefore, the last column of the table column of the table (12th Grade Precalculus/Trig) could not be calculated.

The Path A "On Track" data showed that there was a significant difference from expected to actual enrollment by gender at sophomore, junior, and senior year in all three cohorts, apart from one sophomore grade in one cohort. Next is Chi Square calculations for Path B, Advanced Pathway.

Table 32

Path B-Advanced Pathway χ^2 Analysis by Gender, Cohort 2018

	Geometry to Calculus/AP Calculus AB Pathway Course Enrollment For Graduating Class of 2018 Nebraska Students				
	9th Grade Geometry		10th Grade Advanced Alg.	11th Grade Precalculus/Trig.	12th Grade Calculus/AP Calc. AB
M	3102	48.18%	3189	3028	1331
F	3336	51.82%	3554	3366	1309
			$p = 0.143941$	$p = 0.18634$	$p = 0.021606$

There was not a significant difference between the 10th Grade (Advanced Algebra) and 11th Grade (Precalculus/Trig) groups. In this cohort the only significant difference between male and female enrollment was found among 12th grade Calculus/AP Calculus AB.

Table 33

Path B-Advanced Pathway χ^2 Analysis by Gender, Cohort 2019

	Geometry to Calculus/AP Calculus AB Pathway Course Enrollment For Graduating Class of 2019 Nebraska Students				
	9th Grade Geometry		10th Grade Advanced Alg.	11th Grade Precalculus/Trig.	12th Grade Calculus/AP Calc. AB
M	3090	47.79%	3161	2795	1253
F	3376	52.21%	3595	3190	1299
			$p = 0.099732$	$p = 0.091872$	$p = 0.185115$

The researcher found no significant change in male and female student enrollment across the years in the Path B 2019 Cohort.

Table 34

Path B-Advanced Pathway χ^2 Analysis by Gender, Cohort 2020

	Geometry to Calculus/AP Calculus AM Pathway Course Enrollment For Graduating Class of 2020 Nebraska Students				
	9th Grade Geometry		10th Grade Advanced Alg.	11th Grade Precalculus/Trig.	12th Grade Calculus/AP Calc. AB
M	3174	48.22%	3016	3020	1247
F	3408	51.78%	3365	3369	1249
			p = 0.126001	p = 0.127124	p =0.082349

Again, there was no significant difference between males and females in the 2020, Path B group of students. Review of Path B, "slightly advanced" track data suggests that overall, there is an even and expected distribution of male and female students in these courses. Next is analysis of gender for Path C, Below Average.

Table 35

Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2018

	Prealgebra to Advanced Algebra Pathway Course Enrollment For Graduating Class of 2018 Nebraska Students				
	9th Grade Prealgebra		10th Grade Beginning Algebra	11th Grade Geometry	12th Grade Advanced Algebra
M	947	56.17%	2182	1852	1779
F	739	43.83%	1714	1569	1807
			p = 0.8382359	p = 0.0165944	p = 2.45719E-15

Overall, more males begin in Path C courses at the start of high school in ninth grade. There isn't a significant change in the enrollments of male and female students between ninth and tenth grade. However, the researcher did find that there appears to be a statistically significant difference between the number of males and females enrolled in 11th grade Geometry and 12th Grade Advanced Algebra with male course enrollments outnumbering females.

Table 36
Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2019

	Prealgebra to Advanced Algebra Pathway Course Enrollment For Graduating Class of 2019 Nebraska Students				
	9th Grade Prealgebra		10th Grade Beginning Algebra	11th Grade Geometry	12th Grade Advanced Algebra
M	997	57.83%	2218	1738	1924
F	727	42.17%	1599	1391	1894
			$p = 0.7281455$	$p = 0.0096227$	$p = 1.3223E-20$

The reader may notice some similarities between the 2018 Cohort data and the 2019 Cohort results. This group also begins with a higher male enrollment that grows as expected into tenth grade. The significant difference is again seen in the number of male enrollments being significantly higher in 11th grade Geometry and 12th Grade Advanced Algebra.

Table 37
Path C-Below Average Pathway χ^2 Analysis by Race, Cohort 2020

	Prealgebra to Advanced Algebra Pathway Course Enrollment For Graduating Class of 2020 Nebraska Students				
	9th Grade Prealgebra		10th Grade Beginning Algebra	11th Grade Geometry	12th Grade Advanced Algebra
M	961	57.58%	2201	1905	1991
F	708	42.42%	1671	1589	1898
			$p = 0.3545049$	$p = 0.0002555$	$p = 7.9424E-16$

The 2020 Cohort data tells the same story as the 2018 and 2019 Cohorts. More males start on Path C in Prealgebra and show growth into tenth grade Beginning Algebra is as expected. Looking into 11th grade and 12th grade the researcher identified that another significant gap seemed to appear between female and male enrollment. The overall patterns in the χ^2 analysis showed significant gaps between male and female enrollments in the on track and below average pathways with more male enrollments in both. There is a more even distribution of males and females across the slightly advanced pathway, Path C.

Research Question 2 (Gender) Results

Do the secondary mathematics course taking patterns of Nebraska students vary by gender?

The short answer is yes. Tables 25 – 37 demonstrate this study's analysis of Nebraska high school students' math course taking patterns. Using the three pathways identified from Research Question 1, Path A, B, and C, the researcher reviewed these three paths disaggregating by gender.

This study did find a significant difference between male and female student enrollments in the "Path A: On Track" courses. Cohort data from 2018, 2019 and 2020 showed a greater number of females in the expected values in three years of 10th grade Geometry, three years of 11th grade Advanced Algebra and two years of 12th grade Precalculus/Trigonometry. There appeared to be significantly fewer males in these seven courses than would be expected based on original starting point enrollments in ninth grade. The data included for the 2019-2020 school year did not include a Trigonometry enrollment number and therefore could not be calculated. This led the researcher to question, where the male students who started in this cohort went. One potential answer to this question appeared in the Path C: Below Average Cohort group where another significant difference was found between male and female students at 11th grade. This time male enrollment outnumbered female enrollment with statistically significance in 11th grade Geometry. This change did not carry over into 12th grade with the Path C cohort as more females took Advanced Algebra as seniors in 2/3 years of cohort data. These findings led the researcher to consider the potential that more males may be starting on Track A and taking Geometry as 10th graders but required a second year of geometry as juniors in 11th grade. Essentially dropping into Track C, taking Geometry again as a junior, to earn course credit. There is also the possibility that as students' progress through the grade levels more courses become available to them, and more males take advantage of the additional offerings. Whatever the reason for deviation from the initial course pathway, Nebraska's male student population enrolled in fewer "Path A: On Track" courses than their female classmates, but were enrolled at a higher than expected rate in Path C:Below Average" 11th grade Geometry courses.

In the "Path B: Slightly Above Average" cohort the differences between male and female populations showed significance in 2018 with male enrollment outnumbering female enrollment in 12th grade Calculus/AP Calculus AB or BC. Then in the 2019 Cohort female enrollment outnumbered male enrollment in the same grade and course. In the 2020 Path B cohort there was no significant difference between male and female enrollment found across the grades. These calculations led the researcher to believe there was not a definitive difference across cohorts in the Slightly Advanced Path. Male and female enrollment distributions continued the expected growth patterns. It may be noteworthy to share that in this advanced group the male to female starting percentages were 2018: Male 48%/Female 52%, 2019: Male 48%/Female 52%, and 2020 Male 48%/Female 52%.

Studies referenced and provided in the literature review and introduction had led the researcher to expect findings that revealed an even distribution of male to female enrollments in all courses. This was not the case with this data. The “Path A: On Track” Cohort data showed significantly fewer males than females in all 10th grade Geometry courses, 11th grade Advanced Algebra courses and two 12th grade Precalculus/ Trigonometry classes. There was no trigonometry data for provided for the 2020 year. In the “Path B Slightly Advanced” cohort, no significant difference across the courses or grade levels between males and females was identified. In the “Path C: Below Average” group there were more males than females in 11th grade Geometry and 12th grade Advanced Algebra. A significantly higher number of female enrollments were found in 2018 and 2019’s 12th grade Advanced Algebra classes. In summary, there appear to be an equal number of males and females taking advanced courses, there appear to be more females taking the “on track” path and there seems to be a higher representation of males in just over half of the below average pathway courses. When studying the pathway completion percentages, the researcher also found it interesting that female students across all three Path A cohorts showed slightly higher rates of pathway completion than their male peers. In Path B, the advanced group, the percentage of males completing the pathway was higher in all three cohorts. In Path C, the female population grew from ninth to 12th grade by a much greater percentage.

Summary

In this study of 9th-12th grade math course taking enrollments from 2014-2020, conclusions of race and gender vary by pathway. In Path A the “On Track” pathway, the distribution of course enrollment by race changes as the students complete high school. On Track 9th graders are equal in gender enrollment (approximately 50/50). However, females appear to persist across, sophomore, junior and senior year more than their male peers. In the "Advanced Pathway" or Path B there appears to be an over-representation of white student enrollments that persists into sophomore year. By gender, there is expected distributions of male and female enrollments. Students who start ahead also persist at a higher rate and stay on track through junior year. Path C, the "Below Average" pathway is different from the other two pathways in that enrollment in C increases greatly as students leave Path A and B. The race distribution is significantly different in sophomore, junior and senior than freshman year. While the expected gender distribution sophomore year aligns with 9th grade this does not maintain in junior and senior years.

Chapter Five: Conclusions and Discussions

Alfattal's (2015) Five Principles for Leadership, Equity and Social Justice in Education has motivated and guided this research from its inception. In particular, the analysis of course taking patterns of secondary student in Nebraska provides insight on the Principle of Equitable Opportunities. Educators strive for all students to have access to the best possible educational opportunities including access to rigorous math courses for all students.

We can judge the success of our current educational practices by monitoring patterns of student enrollment. Through this research three main enrollment pathways were identified that represent the course taking patterns of secondary students in Nebraska.

Path A-On Track Course Progression

9th Grade Beginning Algebra	10th Grade Geometry	11th Grade Advanced Algebra	12th Grade Precalculus and Trigonometry

Path B-Slightly Advanced Course Progression

9th Grade Geometry	10th Grade Advanced Algebra	11th Grade Precalculus and Trigonometry	12th Grade Calculus, AP Calculus AB, and AP Calculus BC

Path C-Slightly Behind Course Progression

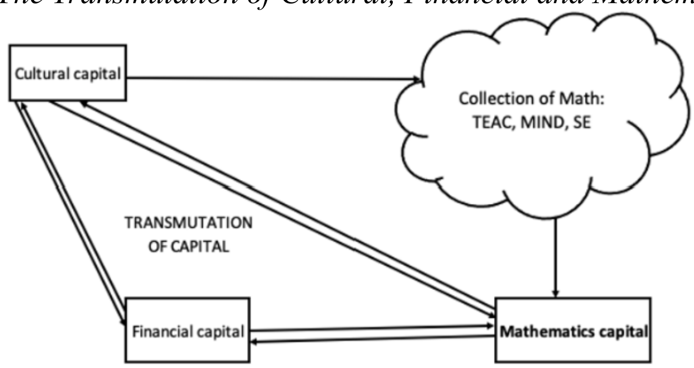
9th Grade Prealgebra	10th Grade Beginning Algebra	11th Grade Geometry	12th Grade Advanced Algebra

There is a dramatic decrease in math course enrollments from 9th grade to 12th grade, many students do not enroll in four years of math in high school. Comparisons of course taking patterns by race show that Asian students appear to persevere through their courses better than other students. African American students do not. This is an area that should be studied further.

National data indicates there is no longer a gender gap present in math courses (Irizarry, 2021). The gender-based results in this research vary by pathway. The results of this study conclude that a student's high school math trajectory depends on ninth grade placement. Just as we learned course taking pattern analysis is not easy, neither is the solution to 9th grade math access. When the significance of the ninth-grade placement is highlighted, the middle school and high school practices that impact those placements must also be considered. In middle school, decisions about math courses start as early as sixth grade and can be influenced by 4th and 5th grade standardized test scores. The future math placement of students is heavily influenced by intermediate grade learning and performance. This may be earlier than many students, parents and even some teachers realize.

In intermediate grades the math experiences lay the foundation that students will build upon in middle school and high school math coursework. This is a critical time for student learning. The researcher's perspective as a former elementary teacher and principal, influences the belief that elementary educators need a strong understanding of mathematics, the progression of math skills and instructional strategies that help students understand the mathematical processes more deeply. These developmental years are so important not only mathematical skills, but in the development of a student's math capital. Just as the traditional definition of capital refers to a form of money or valuable assets owned by a person, Mathematical capital has been defined by Dr. Fran Anderson (2023) as the set of skills, related to mathematics, that are valued by the field of mathematics education, such that these skills allow a person to earn income or to exchange their mathematics capital for other forms of capital. These are the valued skills in mathematics that students can use to earn other forms of valuable capital such as financial or cultural capital (p. 92).

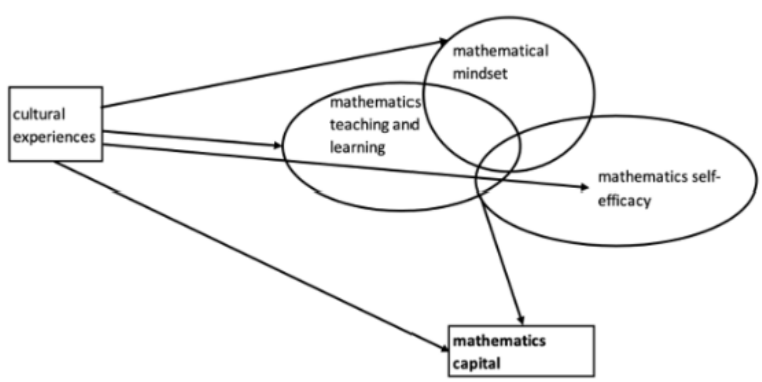
Figure 12
The Transmutation of Cultural, Financial and Mathematics Capital



Anderson, 2023

Elementary school is where students' mathematics capital, cultural experiences, math teaching and learning, mathematical mindset, and math self-efficacy, are established. Once established these beliefs can stay with students throughout their lifetime. Only through intentional effort and determination can these assets begin to grow.

Figure 13
The Research-Informed Model of Factors Influencing Math Capital



Anderson, 2023, pg. 60

In *Visible Learning for Mathematics,* 2016*,* authors Hattie, Fischer and Frey state that, "people who understand mathematics have a higher quality of life. A higher quality of life is often associated with positive cultural experiences and increased financial capital. Anderson (2023) illustrates the conversion potential of Cultural Capital, Financial Capital, and Mathematics capital," (p. 92).

It is imperative for educators at all levels to understand the concept of mathematic capital and the influence daily interactions have on the daily deposits, or withdrawals, of capital into students' math capital accounts. The knowledge of this concept also helps define the importance of high-quality math instruction, it validates the importance and urgency of teachers' daily work. This deeper level of math understanding goes beyond objectives written on the board. From grade to grade starting in preschool the learning experiences we provide students begin to shape their math mindset and self-efficacy. This has a profound and lasting effect on the decisions students make and the courses they chose to take as they leave elementary school.

As educational leaders we constantly balance multiple perspectives simultaneously. We work within the organization and structures that have been created and balance those parameters with individual needs of our students. The patterns that have emerged from this study suggest that a change needs to happen, but as leaders we understand that it must be change that is informed by what is structurally feasible but also necessary for each student's individual needs. When we understand that the options students are given in course taking are among the most powerful factors within the schools control that impact student achievement (Spade et al., 1997), the weight of that statement should cause us to pause and reflect. The courses we offer students, the courses we funnel students into and the courses we encourage students to take is one of the most powerful factors within our control that impacts students' achievement. We create the structures and opportunities for students, in some ways we are the gatekeepers influencing the destiny of students. The sorting and selection process for class placement begins as students transition from elementary to middle school typically around fifth or sixth grade. This is a well-intended practice designed to teach students at their level and provide more heterogeneous class groupings for instructors. The researcher urges current educators in the field to reflect and review your current practice around student placements, which can also commonly be referred to as tracking. Tracking occurs when we label and group students, putting them in courses that will determine their path through high school. It's important to consider the possibility that by doing this, we may be unintentionally limiting student learning opportunities and exposure to more rigorous content. This process may put a ceiling on the learning potential of certain groups of students. Although the process of tracking has reduced significantly in recent years, and students are offered a greater number of course choices than ever before, resulting in curriculum differentiation is prominent in math (Tyson & Roska, 2016).

Differentiation has become a commonly used educational term with a typically positive connotation. It's generally defined as instruction designed to fit the needs of each student. In practice, differentiation has translated to well-intended instruction delivered in a variety of different ways. In elementary classrooms, students may be divided up small groups based on ability levels determined by test scores and the teacher's assessment of their skills. In middle and high school differentiation may come in the form of different course options. Differentiation is designed to give students multiple options for taking in information, making sense of ideas, and expressing what they learn (Tomlinson, 2017). It sounds good but we need to consider what happens when we place students at a lower level instructionally. We need to consider the idea that we are widening the learning gap between our students. If lower achieving students are never exposed to the higher-level content, it's possible to consider that they are losing ground compared to same age peers (Attewell & Domina, 2008; Hallinan, 1994; Oakes, 2005). Even students who succeed in remedial courses have difficulty moving into higher-level courses if their placement resulted in missed content needed for the next level (Tyson & Roska, 2016; Hallinan, 1994; Oakes, 2005). When looking at our current practice of differentiation through this lens the researcher again considered elementary structures where all students receive the same instruction in math from PreK-5th grade and differentiation is implemented in small groups outside of whole group learning to either reinforce or enrich student learning. This practice and structure ensure that all students have equal access to grade level curriculum, then students are supported based on individual need outside of that lesson. Then as students' progress to middle school we change that structure and begin placing students in pathways or tracks that in some cases limit their exposure to "On Level" curriculum. There are no easy answers, simply increasing course difficulty for all students has been met with mixed results. "Algebra for All" initiatives in the 1990s along with other mandated initiatives intended to increase rigor for all students have been tried across the country. Research based on "College Prep coursework for all mandates" enforced in Chicago on ninth graders suggested that universalizing high level coursework for all students did not work in urban areas. Although more students took Algebra in ninth grade, failure rates increased, grades declined, test scores did not improve and students were no more likely to go to college (Allensworth et al., 2009). The author of this research report goes on to discuss and explore the reasons for this policy's apparent failure. Some reasons mentioned included the potential lack of additional resources needed for a change effort of this magnitude such as additional student support along with additional staffing and teacher training or support. An opposing conclusion is offered from Gamoran and Hannigan from 2000 out of the University of Wisconsin. They simply state that all students, regardless of prior math skills, benefit from taking high school algebra. Students at the bottom of the achievement distribution gain less that others, but they still benefit. Any given student should enroll in Algebra to maximize his or her achievement (Gamoran & Hannigan, 2000). The authors do not say specifically at what grade everyone should take Algebra, but they indicate before high school or in early secondary school. Whether it is Algebra for All or other initiatives, if we want to create equity for all, it needs to be about personalized learning and not about the efficient logistics of course scheduling. Perhaps it's time to turn current educational practices on their head and dig into the reality our data presents. Maybe we need to take students out of their comfort zone in their learning and provide creative solutions to student and teacher support when they struggle with content rather than limit student access to content.

To remedy this, students must be active participants in their course selection and encouraged to learn outside of their comfort zones. This practice requires teachers who are willing to help struggling students by providing them additional learning time and support when the content becomes challenging. If math learning at high levels can be achieved by all students with proper pre-teaching and support, we must continue to open doors to all students and encourage them to pass through those doors. As educators we should never be in the business of limiting the potential of hardworking students or placing a ceiling on their mathematical capital.

Supportive parents, teachers, school counselors and administrators can play an important role in encouraging students to accept the challenge of more advanced coursework. Students often rise to the expectations that the adults in their lives have for them. The number one most influential predictor of a student's academic achievement in Math was parental expectations and aspirations for their child (Fan & Chen, 2001). Approachable teachers who build positive, supportive relationships will allow students to come to them for academic support when content becomes challenging.

Recommendations for Future Research

When studying student enrollment and course pathways through high school it's like completing a puzzle with a missing piece when you don't know the students' aspirations and goals. It would be exciting to continue looking at the next steps taken by these cohort groups after graduation. Another key motivator for taking certain courses is college admittance requirements and career aspirations. This is a key piece of information that would be helpful in the specific study of STEM course taking and the choices made by students based on gender and race.

Course enrollment by race yielded similar results to national data. It was interesting to dig deeper and consider pathway completion by race. Future research surveying parents and students to understand personal reasons for continuation of courses may be helpful in working to correct underrepresentation of African American students in math courses. This data could also provide insight as to why some groups of students seem to "stay the course" from ninth to 12th grade and others may deviate from the intended path.

Finally, as a former elementary teacher and principal researching and exploring an entirely new world through this work, continued research around elementary math instruction is needed in many areas. Understanding the impacts of teacher self-efficacy on the quality of their math instruction would be fascinating. It's not a stretch to consider that teachers who were good math students have a strong foundational understanding and may be better suited to teach others. In addition to teacher capacity and self-efficacy, teacher personal bias toward content may impact student learning. This could be done at both primary and intermediate elementary grades; both are equally important but vastly different in content and philosophies.

The opportunities to explore data sets of this size and nature are rare. It is the hope of the researcher that this work can continue through the partnership with the Nebraska Department of Education for future graduate students. Future studies need to analyze elementary and middle school as well as unpack why and how students are funneled into certain classes. Access to course taking patterns can inform and potentially reform practices to guarantee equal access for all to the courses and careers they desire.

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