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NECESSARY CONDITIONS: Understanding patterns and variations in math course-taking among high school seniors to increase completion of four years of math

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NECESSARY CONDITIONS: Understanding Patterns and Variations in Math Course-Taking Among High School Seniors to Increase Completion of Four Years of Math

by

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DISSERTATION

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2024

NECESSARY CONDITIONS: Understanding patterns and variations in math course-taking among high school seniors to increase completion of four years of math

Abstract

This mixed methods study explores high school seniors' math course-taking decisions and what changes school leaders can take to increase the percentages of students taking four years of math in high school. Through an analysis of district-level administrative data and a survey completed by seniors at a high performing, diverse high school in Northern California, this study illuminates many reasons for why these patterns and inequalities occur. Findings reveal institutional, classroom and individual factors that impact students' decision-making around taking math senior year.

Keywords: secondary math course-taking, seniors, high school math pathways, equity in math

Dedication

Far more of this dissertation research and writing than I care to admit happened in the back seat of my car while my sons were at water polo practice. For me, this dissertation will always be intertwined with a realization of the craziness of youth sports and realizing I could do much of an entire doctorate program while waiting on my kids at practice.

I would not be here if not for the over 1000 students I have taught in my career as a math teacher. Each of them has made me a better human, teacher, and school leader. My students and their families have changed my perspectives in countless ways and without them, I would never have come this far in my leadership journey.

My three years in CANDEL and the completion of this dissertation is dedicated to Mike, my husband, and two amazing sons, Egan and Mason, whose patience and unyielding laughter and love has kept me going. Thank you for believing in me and giving me so much grace throughout this journey.

Acknowledgements

As I was thinking and rethinking my analysis chapters, songs would come to me about seeing light through the darkness. “Suddenly I See” by KT Tunstall, “I can See Clearly Now” by Jimmy Cliff are ones that remind me of this process of having so many notes, read so many articles, organizing so much data and how themes started to jump off the page when I least expected it. I learned to trust the process and keep moving along when I felt like I had lost my way.

The first part of the title of this dissertation, Necessary Conditions, is a nod to Geoff Krall’s book, Necessary Conditions: Teaching Secondary Math with Academic Safety, Quality Tasks, and Effective Facilitation (Krall, 2018). Just after his book was published, after several years as an administrator in a district office, I returned to teaching middle school math. I appreciated this idea of narrowing in on what are the necessary conditions which will lead to higher success for students in secondary math classrooms. As I embarked on possible topics for this dissertation, I kept returning to this idea of wanting to research the highest-leverage factors, or necessary conditions, needed to positively impact math outcomes for high school students.

There are so many people to thank over the past three years who have shared their wisdom, lifted me up, taken things off my plate and reminded me that this degree is worth the sacrifices.

#quarentine17. The best CANDEL cohort, which will one day be proven through a mixed-methods study. Ya’ll never cease to inspire me. A special thanks to Katrina whose wisdom and ability to create joyful moments amidst the struggle got me through so many ups and downs over the past three years. And our East Bay carpool which had so many good laughs with a whole lotta caffeine from Dutch Brothers along the journey.

I am so grateful to all our CANDEL professors, particularly Dr. Mustafaa for her wisdom and humor, Dr. Beno for her amazing ability to provide the perfect feedback at the just right moment, and Dr. Montaño for continually reminding me of the power of student voice. Finally, I have so much gratitude for my committee: Dr. Kurlaender, my advisor, whose wisdom, warmth, friendship, direct feedback, and truly phenomenal ability to help me see the core issues of any topic were such an inspiration and Dr. Montaño and Dr. Wallace who each pushed me to strengthen and sharpen my analysis. I'm here today because of you and I so deeply thank you for that.

Before accepting a job as a high school assistant principal, Dr. Montaño warned me that it would be extremely hard to be a new site administrator while also beginning CANDEL. She was not wrong. To Robert Ithurburn, my principal, who gave me so much grace as a new administrator and CANDEL student. I missed every assembly and plenty of other things for the first two years of my job and while he undoubtedly had private opinions about the matter, he was one of my greatest supporters. Additionally, Lindsey Stark-Jenkins, my district's Senior Manager of Research, Assessment and Data was so incredibly helpful as a regular thinking partner and data guru. I'm hoping to be just like her one day when I grow up.

Finally, I wouldn't be here without my family. My parents' excitement for me kept me going throughout these three years. Mike, Egan and Mason, I love you beyond words. You each gave up a lot over the past several years to make sure I got here. You kept me going when I felt I was too old to be getting a doctorate and constantly reminded me that it was worth it. We have a lot to celebrate together.

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CHAPTER 1: INTRODUCTION

As a child, I was an extremely advanced math student. As an educator, I often reflect on the question: "Why me?" In college, I finally began to understand the layers of privilege involved in my parents' advocacy for my advancement in math, including our whiteness, my parents' leisure time, and their knowledge of the educational system. Also in college, I turned away from math and engineering because of a deep desire to disassociate myself from the competitive, individualistic personalities of my advanced math peers. I have been on a three-decade-long personal journey to better understand the outcomes of math acceleration with an equity lens, and the purpose of early acceleration—beyond creating a shiny gold star on a college application.

As a former middle school math teacher and a current high school assistant principal overseeing a large math department, my equity work focuses on two core values: relationships between students and teachers and pedagogy. Those values are necessarily intertwined with educational pathways and course-selection policies—the backbones of a student's experience in math classrooms. Gutiérrez (2002) defines educational equity as "…being unable to predict student patterns (e.g., achievement, participation, the ability to critically analyze data or society) based solely on characteristics such as race, class, ethnicity, sex, believes and creeds, and proficiency in the dominant language" (p. 153). This definition of equity resonates with me as a high school assistant principal because of its focus on eliminating predictability through so many lenses.

Problem Statement

Teenagers' math abilities, as measured by the National Assessment of Educational Progress (NAEP), have been declining for every racial group since 2012 across the country,

hitting new lows in 2023 (Nation's Report Card, n.d.). Declining math scores are significant for several reasons, as the amount of math taken in high school continues to be positively correlated with numerous long-term outcomes including college GPA, earning a college diploma, and higher wage earnings (Conley, 2006; Gao, 2021; Hayward, 2021; James, 2013; Rose & Betts, 2004, Trusty et al., 2008). In fact, a longitudinal, national study of students attending four-year colleges straight out of high school found that just one additional advanced math class in high school more than doubled a student's likelihood of finishing their college degree (Trusty & Niles, 2003). As college graduates earn an average of 70% more than graduates with only a high school degree (Markow & Bagnaschi, 2005), math scores can have considerable effect on long-term student outcomes. In other words, declining math scores mean that fewer students are prepared to succeed in advanced math courses in high school, which affects their access to positive outcomes in adulthood.

Multiple comprehensive reports detail California student enrollment in four years of high school math and advanced math (Asim et al., 2019; Reed et al., 2023c, Reed et al., 2023b). Reed et al. (2023b) found that only 54% of California high school seniors are enrolled in an advanced math course (above Algebra 2), and only 75% of all high school seniors are enrolled in any math course. Of the 54% of high school seniors taking advanced math, there are inequalities by race (Reed et al., 2023b). While 73% of Asian-American and Pacific Islander seniors and 52% of white seniors are enrolled in a math class above Algebra 2 in California, just 46% of Latinx seniors and 41% of Black seniors take math beyond Algebra 2 (Reed et al., 2023b).

There is little research on the specific factors that prevent more students from taking a fourth year of math in high school, particularly in advanced math classes (Reed et al., 2023a). Each of these reports by Reed and her colleagues from the Policy Analysis for California

Education (PACE) describe the racial disparities among students taking advanced math in high school. This study will examine factors that can improve conditions for access and opportunity for all students to take and succeed in high school advanced math classes. In my career as a secondary math teacher, district administrator and now high school vice principal, I have witnessed firsthand that there is often a dearth of knowledge among school and district leaders on the high leverage factors to prioritize when advocating for equity; this study aims to narrow that knowledge gap.

California is one of only three states requiring just two years of math for high school graduation; the remaining 47 states required three or four years of math for high school graduation (Burdman, 2022; Gao et al., 2017; Moussa et al., 2020). A 2022 study by the Charles A. Dana Center found a correlation between California's two-year math graduation requirements and comparatively low rates of students taking four years of high school math. To address the disproportionality in enrollment in advanced high school math, the 2023 California Math Framework suggested diversifying math pathways through increased offerings of data science and statistics courses as alternatives to the traditional Algebra 2 → Pre-Calculus → Calculus pathway (California Department of Education, 2023a). The 2023 California Math Framework formalized the development of additional advanced high school math courses, which originated through grant funding via the 2016 California Math Readiness Challenge (California Department of Education, 2022a).

Despite only two years of math required for California high school graduation, public four-year universities in California require students take a minimum of three years of math to be eligible to apply (California Department of Education, 2023b). Three years of high school math is one of the seven entry requirements for both California State and University of California

postsecondary systems, often referred to as the A-G requirements (California Department of Education, 2023b). Beginning in 2016, the California State University (CSU) system researched two possible policy changes for high schools: requiring a fourth year of math as part of the A-G entrance requirements and promoting 12th grade quantitative reasoning courses that are not part of a calculus pathway (Academic Senate of the CSU Quantitative Reasoning Task Force, 2016). Consideration of these math policy changes for California high schools coincided with the state designating $6.4 million to further develop new math courses for 12th graders with the aim of increasing the percentage of students taking four years of math (Burdman, 2018).

After several years of deliberation and research, the CSU system decided in November 2022 to not raise their entrance requirements to four years of high school math, instead investing in math preparation and supporting the transition from high school to college (Burdman, 2022). Yet, as detailed above, recent reports show numerous positive outcomes for students who do take math throughout high school (Burdman, 2022). Wainstein et al. (2023) studied several outcomes among students taking four years of math on college access in the Los Angeles Unified School District: cumulative GPA at graduation, completing A-G requirements, college enrollment, and continuing onto a second year of college. To further refine their findings, they grouped students by similar course-taking histories based on grades and number of math courses beyond Algebra 2 before 12th grade. For students across all course-taking clusters, they found that taking math in 12th grade had minimal negative effects on students' GPAs; significant positive effects on four-year college eligibility among students who had not completed their A-G requirements prior to senior year; and a medium, positive effect on four-year college enrollment and persistence. Additionally, students who began senior year without having met their A-G requirements either because they had a D in a previous course or because they had not yet taken three years of math

were much more likely to be four-year college eligible after taking math senior year. Even students who had already met their A-Gs by 11th grade benefitted by taking math in 12th grade, as they were more likely to enroll and persist through a second year of four-year college The effects of four years of high school math are clear, despite California's decision to only require two years of math for graduation.

Key Constructs

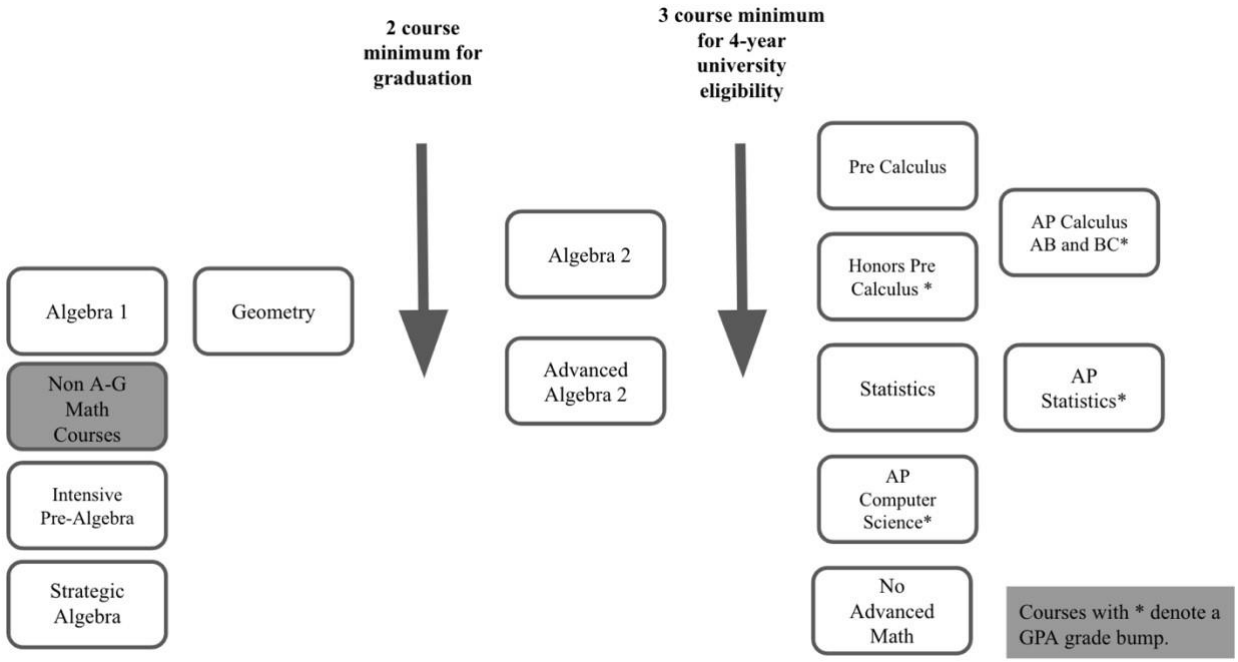
The following concepts form the crux of this exploration:

- **A-G subject requirements**: To meet the minimum requirements for admission to a school in the California State University or a University of California systems, there are 15 required courses where students must earn a C or higher (University of California, n.d.). The minimum acceptance requirement for math is three years of college preparatory courses, including Algebra and two- and three-dimensional geometry (University of California, n.d.).
- **Advanced math:** Students need three years of math to meet their A-G requirements and become eligible to attend a four-year California university. California math course sequencing follows the state-adopted Common Core State Standards. There are two pathways outlined: traditional and integrated. The first three years of the traditional pathway are: Algebra 1, Geometry, and Algebra 2. The first three years of the integrated pathway cover similar content but integrate Algebra and Geometry into three years: Math 1, Math 2, Math 3. For purposes of this study, any math class beyond Algebra 2 is considered 'advanced math': Statistics, AP Statistics, Pre-Calculus, and Calculus.

- **Fourth year of math:** Throughout this paper, the terms "seniors taking math" and "fourth year of math" are used interchangeably.[1]
- **Math pathways:** This term refers to course sequencing options for students to meet their A-G requirements and take a fourth year of high school math. A sequential list of math courses offered at Waterview High is shown below in Figure 1.

Figure 1

Math Courses Offered at Waterview High



Purpose

The purpose of this study is to learn more about the math course-taking patterns of

[1] As there are fewer than ten fifth-year seniors, they are not considered separately.

California high school seniors. A specific aim is to discover why just 54% of students take an advanced math class beyond Algebra 2 and what factors lead to the underrepresentation of Black and Latinx students taking advanced math. By centering the voices and experiences of seniors at Waterview High[2], a large, suburban high school in the San Francisco Bay area, this study interrogates why 12th graders end up taking or not taking a fourth year of math.

Unless a district has graduation requirements more than the state's two-year requirement, taking math courses become optional at some point in high school. While Reed, et. al., (2023b) breaks down who is and is not taking a fourth year of math by race, 11th grade standardized test score, and grades in prior math classes, these descriptive statistics do not necessarily help high school and district administrators know why these trends are true or how to affect and equalize math course-taking.

This study examines some of the additional interrelated forces that may influence why students do not take a fourth year of math in high school or never take an advanced math course beyond Algebra 2. This investigation asks: how do scheduling decisions, counselor influence, course offerings, prior grades in A-G coursework (math and non-math courses), and fulfillment of other A-G coursework influence students' math pathways? How does a students' sense of belonging in math class—and whether they see the math they are learning as relevant to their future—affect their decision of taking math in 12th grade? From my perspective as a math teacher and school leader, math is a subject-area that students that many students find

[2] Waterview High School is the pseudonym used throughout this dissertation for the actual high school located in the San Francisco Bay Area where I work as the assistant principal.

challenging or dislike so focusing on these social factors are one way schools can increase positive associations with it.

Significance

Since California districts use A-G completion as a crucial indicator of success and colleges place a lot of value on taking math course taking, this study's research questions are directly relevant to state educational policy. With this in mind, this study identifies key areas for districts to focus on when working to improve secondary math outcomes in, among other places, K-12 math task forces. To attain Gutiérrez's (2002) equity goal of eliminating predictability by race, policymakers must first establish knowledge of who is taking math in 12th grade, then dig into which factors most influence students' course-taking trajectories.

Another reason to understand students' math course-taking trajectories is that there are very diverse opinions on the long-term value of taking Algebra 1 prior to high school. Anecdotally I know that secondary math teachers often believe that students who accelerate their math learning beginning in middle school do not develop the depth of understanding needed for success in calculus and beyond. Middle school math acceleration often begins with parents pushing students to accelerate in hopes of an advantage when applying to college; however, students themselves are not always motivated to continue to challenge themselves in math and may experience discouragement with the material or burnout before their senior year. More recently, California has developed advanced math courses such as data science in an effort to offer more types of math beyond the traditional Algebra 2 to Pre-Calculus/Calculus pathway, which many students do not see as relevant to their higher education or career plans and which may further contribute to burnout in math learning (Burdman, 2022).

Research Questions

This mixed-methods study is guided by the following overarching research question: What patterns and inequalities can be observed in math course-taking among seniors at a high-performing, diverse suburban school? To this end, this study explores the following sub-questions:

1. What are the patterns in fourth-year math enrollment by demographics and prior academic achievement at a high-performing, diverse suburban school?
2. How do seniors explain what prevented or facilitated their decision to enroll or not enroll in math their senior year?
    a. How do seniors perceive their experiences in math classes and the importance of taking advanced math classes in high school?

CHAPTER 2: THEORETICAL FRAMEWORK

My research is centered on the factors that influence whether 12th grade students enroll in and successfully complete math in their fourth year of high school. Both theory and data show that students do not end up on their course-taking pathways accidentally. Systemic mechanisms sort students into education pathways that interact with classroom and personal experiences, where students have found success (or lack thereof).

Many factors influence course destinations. Some are specifically related to students' prior experience in math courses, and some are not. Factors include whether a student likes math and/or perceives that an additional year of math is important to their future. Others could include: Are there enough sections in a school's master schedule for all students who want to take advanced math classes? Are there options for which math classes 12th graders can take? Do students have outstanding graduation or A-G college requirements they have not yet fulfilled? Ultimately, these factors do not fit neatly into clearly delineated categories. Each of these factors are interrelated and often influenced by seemingly small and discrete decisions or actions, such as how many seats are available in a class; a conversation with a counselor, teacher, friend or family member; or even whether or not a school offers alternative ways to get credit for graduation requirements, such as PE waivers for sports teams.

Constrained Choice Theories

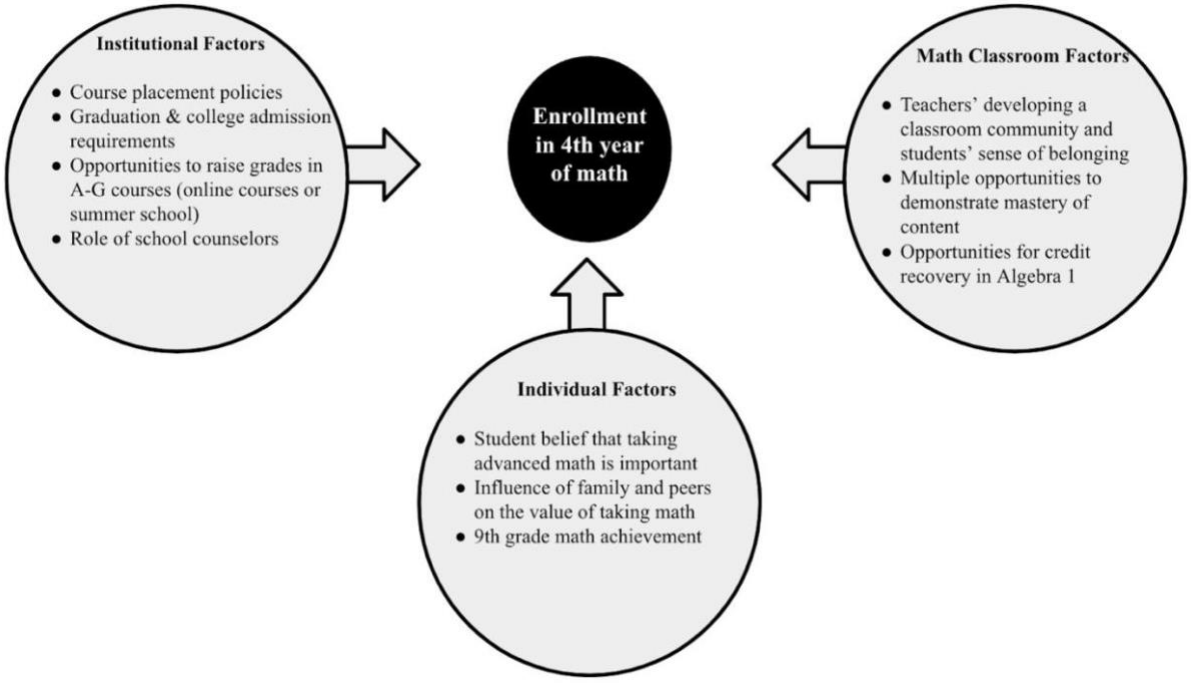
Kurlaender and Hibel (2018) summarize research theories of constrained choice for students' academic pathways. They explored the notion that many decisions students make in course pathways are wrought with constraints, a "tension between individual choice and structural constraints" (Kurlaender & Hibel, 2018, p.361). Their framework for organizing these

constrained choices has three categories: educational aspirations, curricular differentiation, and informational barriers and opportunities.

Likewise, Thompson's (2017) study of the factors affecting English Language Learners' math course-taking patterns in high school explained how math course-taking outcomes are influenced by many factors, some of which are under a student's control and some which are not. This study developed a conceptual framework explaining the intersecting factors affecting math course-taking: Key Institutional Factors (Course placement policies), Classroom Factors (Ways of knowing), and Individual Factors (Motivation). These three intersecting influences are defined as math course-taking ecologies. Although prior research explored each of these factors separately, Thompson was the first study to examine the interconnectedness of these factors in high school students' math course taking outcomes. How these intersectional factors apply to my study on 12th graders' math course-taking decisions is visualized in Figure 2 below.

Figure 2

Conceptual Framework for Math Course-Taking Ecologies (Adapted from Thompson, 2017)



CHAPTER 3: LITERATURE REVIEW

Although several recent studies offer rich descriptive statistics on who is taking four years of math in high school and what course pathways led them there (Asim et al., 2019; Reed et al., 2023b), few comprehensive studies examine why some students are opting out of math in their senior year (if not before). Although a fourth year of high school math is not often required for graduation nor college admission, many studies demonstrate a positive correlation between taking higher-level math in high school with higher grades, college admission rates, and future earnings (Conley, 2006; Gao, 2021; Hayward, 2021; James, 2013; Rose & Betts, 2004). It is important to note that most of the links drawn in this literature are correlational and not causal; that is, the same factors that led students to enroll in math in their senior year (e.g., motivation, support, prior academic achievement) are likely also some of the same factors that lead to these other positive outcomes. Descriptive statistics about who is not taking four years of math are critical to this analysis. Finally, Thompson's (2017) conceptual model for math course-taking provides the framework for discussion of three themes contributing to these patterns: institutional factors, classroom factors, and individual factors. Each of these categories is deeply interconnected with the other two, making distinct categorization at times impossible.

Why is Taking Advanced Math Classes in High School Valuable?

There is both short- and long-term value in taking as many years of math in high school as possible. Success in secondary math has been correlated to better higher education outcomes. Adleman (2006) found that students who took a math course beyond Algebra 2 saw improved rates of graduation from college. A more recent focus in California has been to increase the course options available to students after Algebra 2. Hayward (2021) posed the question of whether these new courses (i.e., options beyond the traditional precalculus-to-calculus track) will

increase interest in math courses for students who may have opted out after completing Algebra 2. In his study of over 400,000 California community college students, Hayward (2021) found that the number of math courses a student takes in high school is positively correlated with higher high school GPA. Looking at how math courses in high school can influence higher education outcomes, Adelman (2006) found a positive correlation between years of math in high school and the likelihood of earning a bachelor's degree. "The highest level of mathematics reached in high school continues to be a key marker in precollegiate momentum, with the tipping point of momentum toward a bachelor's degree now firmly above Algebra 2" (Adelman, 2006, p. xix). Students who take Advanced Placement (AP) and International Baccalaureate (IB) programs in high school are also more likely to experience success in college as measured by increased scholarships, grades and graduation rates (Kettler & Hurst, 2017).

While some scholars have only looked at the impact of math course-taking on GPAs and graduation rates (both high school and college), others have found that taking more math in high school is positively correlated with earnings (James, 2013; Rose & Betts, 2004). Using 10-year data from the National Longitudinal Study of Youth, James (2013) found that regardless of high school graduation status, higher levels of math taken in high school led to substantially better earnings and levels of employment. These results held true for both college and non-college bound students. This study found that taking more math courses in high school is positively correlated with whether students will attend college .

Advanced math in high school is also an important component of preparation for becoming a STEM major in college. In 2015, the Bureau of Labor and Statistics found that the national average for wages for STEM jobs was twice as high as for non-STEM professions (Park-Taylor et al., 2022) and that there has been a 26% wage increase in STEM jobs since 2010

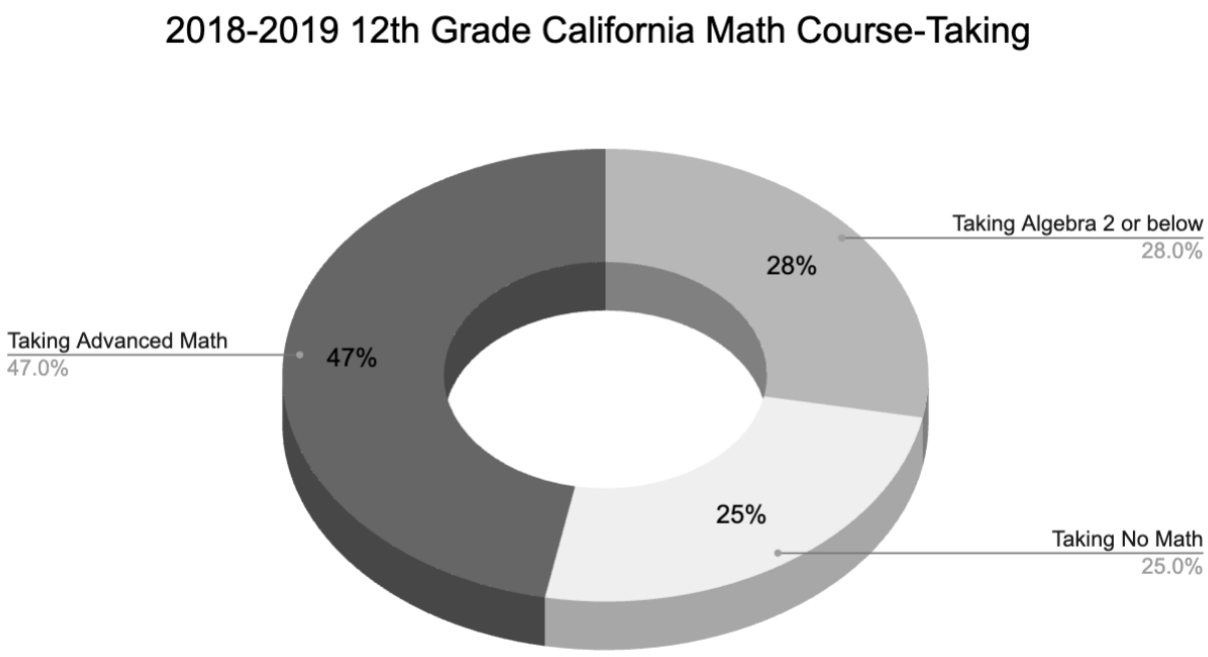
(Noonan, 2017). By virtue of these figures alone, this implies that taking advanced math in high school may result in higher wage earnings via the STEM profession pipeline.

What is Known About High School Math Course-Taking in California?

Using student and course-level data from the California Longitudinal Pupil Achievement Data Set (CALPADS), Reed et al. (2023b) examined the math course-taking patterns of California seniors graduating in 2019. Three years of high school math is the minimum requirement for eligibility to a -year university. Those three years of math traditionally include Algebra 1, Geometry and Algebra 2. Figure 3 illustrates that less than 50% of 12th graders take any math class beyond Algebra 2, and 25% do not take a fourth year of math.

Figure 3

Advanced Math Course-Taking by California Seniors (Summarized in Reed et al., 2023b)



Of the 12th graders who take Algebra 2 but advance no further, 54% earn a C or higher, making them not A-G eligible even after meeting the required three years of math for entry into a four-

year college. Additionally, this study found large disparities by race, socioeconomic status, and English Learner status in who takes advanced math. The study concluded with an area for future study: how can course pathways beyond the two traditional calculus and statistics tracks be leveraged to increase interest and success in more math coursework?

Institutional Factors Influencing Why Students Do Not Take Four Years of Math

Institutional factors affecting weather a student takes a fourth year of math include course placement policies like tracking (detailed below), graduation requirements, state requirements for college admission (A-G requirements in California), opportunities to raise Ds and Fs to regain college eligibility, and the role of school counselors (among others). None of these policies or practices are directly in a student's control, but any can be a contributing factor into whether a student is able to take—or chooses to take—math in all four years of high school.

Math Tracking Policies in California

Tracking policies in math often pre-determine—even well before students are in high school—the math classes available to students at each grade level, and ultimately impact what advanced math courses a student is eligible to take by their senior year. Individual school policies mandating various types of coursework for students similarly affect math course options.

The historical roots of tracking lie in educational initiatives introduced with the aim of increasing the United States' global competitiveness (Oakes, 1985). Some scholars have questioned the potential benefits of tracking versus the harm it can cause. For example, in their meta-analysis of the impact of tracking on student achievement, Terrin and Triventi (2023) reviewed research spanning both tracking within schools and tracking within a district where different schools offered different levels of programs. Summarizing the benefits of tracking,

they noted that teachers found it easier to teach classes where students' abilities and level of engagement were more homogenous, and that it can be more efficient to train students for specific labor market needs when students are sorted by both ability and levels of interest. The harmful effects of tracking most affected students sorted into the lower tracked classes. Sorting was often influenced by the subjective bias of school staff, who made the decisions on who was capable of succeeding in higher-track classes. The earlier students were sorted into ability groups, the more likely the decision was inappropriate, as much less is known at younger ages about a student's desire to work hard and how the cognitive and non-cognitive skills needed for higher achievement will matureThis study also found that tracking also penalizes students from lower socio-economic backgrounds whose families may not have the institutional knowledge, power, or financial ability to navigate the system or the means to rely on outside tutors for additional support.Additionally, tracking creates a tiered system where the most qualified teachers are often teaching the highest tracks. This exacerbates and perpetuates social inequality, as it creates a system where lower-track classes may not receive the same quality of education as higher-track classes (Terrin & Triventi, 2023).

In their meta-analysis of 53 quantitative studies on the impact of tracking, Terrin and Triventi (2023) conclude that there is no statistically significant impact of tracking on the efficiency of the educational system for future job preparation, and that there is a statistically significant positive impact on increasing inequalities in schooling and academic achievement. They conclude that detracking reforms reduce inequalities in academic outcomes and opportunities while having no negative effect on overall student achievement.

Tracking in math, wherein multiple levels of math classes are offered within a single grade level, often *officially* begins with Algebra 1 in middle school, but in actuality can be

introduced much sooner. In her seminal study of the impact of tracking on long-term outcomes of students in both higher- and lower-track classes, Oakes (1985) studied the experiences of over 13,000 middle- and high-school students at 25 schools. She found that informal tracking happened in classrooms much earlier, with reading groups and math groups streamlined by perceived ability often starting in kindergarten. Furthermore, in California middle and high schools, there is no standardized selection process between districts on how students ultimately end up in their math track; initial decisions in middle school are often up to teachers' discretion, which can be based on assumptions about race or socio-economic status instead of a student's desire to be in an accelerated math class (Wells, 2018). This sorting by math teachers has led to inequitable access to higher-level tracks. Students from historically underrepresented racial groups often face racial bias from teachers and are systematically placed in less rigorous math courses (Wells, 2018).

Once placed in a math track, students often face different levels of teacher quality and experience, with less experienced and less qualified teachers often being required to teach the lower-track classes as they are often less desirable teaching placements (Wells, 2018). In her study on successful math departments, Gutiérrez (2000) reports that a greater sense of department-wide responsibility for all students results when teaching schedules are rotated each year so that all teachers are exposed to a wide range of students' abilities through teaching all levels of math. Historically, tracking in math classes has been defined by both racial and socioeconomic divisions, with lower-income students and students from some racial/ethnic groups (e.g., Latinx and African American/Black) more likely to be placed in lower-track math courses relative to their White or Asian peers. This has led to assumptions that a student's race and academic success in math are correlated, and that students from historically

underrepresented groups cannot succeed in higher tracked math classes (Modica, 2015, as cited in Wells, 2018).

Additionally, math tracking that begins in middle school can affect the math-taking habits of students attending community college (Ngo & Velasquez, 2023). In their research brief discussing the long-term outcomes of math course selection processes, Fong and Finkelstein (2014) found that middle school math placement policies and subsequent math achievement were significant factors in who had access to college-level coursework in high school. Furthermore, in their quantitative study linking urban community college students' transcripts to their feeder high schools, Ngo and Velasquez (2023) found that 92% of California community college students repeated a math course from high school while in college, and only 29% of California community college students ever took a math course above and beyond the highest level of math they took in high school.

In California, state policy has dramatically shifted on the issue of when students are recommended to take Algebra 1. In 2008, the California State Board of Education voted to make Algebra 1 the only math content of the standardized test for eighth grade, which led to districts offering Algebra 1 to all students to comply with federal No Child Left Behind policies (Rosin et al., 2009, as cited in Domina et al., 2014). While the intention behind having all eighth graders take Algebra 1 was rooted in democratizing access to advanced math classes in high school via the raising of standards for all middle school students, the impact was that a huge proportion of students failed Algebra 1 and had to repeat it in high school (Loveless, 2008). Results of this policy shift—sometimes called the "Algebra for All" movement—were mixed overall, as some studies showed that enrolling relatively high-achieving students in eighth grade algebra had positive outcomes (Domina et al., 2015). In their summary of outcomes from

California's Algebra-for-All era, Stein et al. (2011) explained that this universal mandate created false positives, meaning that students without adequate math prior knowledge failed Algebra 1 and had to repeat it in high school.

Over a decade later, California now recommends delaying all math tracking until high school, with a strong recommendation that all eight graders take an untracked Common Core State Standards (CCSS) 8 math course, and delay Algebra 1 until ninth grade (California Department of Education, 2022a). They explain that rushing through math courses may not provide needed depth of understanding to achieving a solid foundation in mathematics. The California Department of Education goes on to suggest finding ways for students who don't accelerate in eighth grade to still have the opportunity to reach Calculus by twelfth grade. These recommendations have been met with varying levels of support and opposition. This controversy meant that the adoption of the state's math frameworks was delayed several times (Fensterwald, 2022).

Anticipating this policy trend, San Francisco Unified School District (SFUSD) eliminated all middle school math tracking beginning in the 2014-2015 school year (Huffaker et al., 2023). In their longitudinal study of six cohorts of SFUSD high school students after the introduction of this math pathways reform, Huffaker et al. (2023) noted the SFUSD's policy decision had two main goals. First, eliminating all middle school math tracking was intended to provide more equitable opportunities for learning for all students. Second, elimination of course tracking created the opportunity to build a stronger foundation of pre-algebra skills in middle school for all students. As a result, the hope was that a larger proportion of Black and Latinx students would be prepared to succeed in advanced math by 12th grade.. Unfortunately, after studying six years of graduating seniors, Huffaker et al. (2023) found that Black student enrollment in AP courses

(both AP Calculus and AP Statistics) was statistically unchanged, and Latinx enrollment only increased by one percentage point.

Importantly, the SFUSD's experiment had limitations that may have contributed to this outcome. One limitation was the district's policy that a student had to pass the prior course to take a subsequent course (i.e. pass Geometry to take Algebra 2), and Huffaker et al. (2023) did not study whether the district provided additional programs to ensure all students had the necessary support to reach higher levels of math course-taking. Although SFUSD's elimination of tracking did not achieve its goal of reducing the disproportionality of Black and Latinx students in AP math classes, further study is needed to measure equity implications of eliminating middle-school math tracking.

Ultimately, Dr. Linda Darling-Hammond, the 2024 president of the California State Board of Education, has long argued that tracking in mathematics causes opportunity gaps, which ultimately lead to huge achievement gaps in high school and beyond (Darling-Hammond, 2006). Continued work on finding the balance between ensuring that all students are adequately challenged and supported is warranted to address these systemic inequalities.

High School Graduation and College Admission Requirements

Many high schools have tried to increase enrollment and reduce imbalances across racial groups in advanced coursework by threading more math into graduation requirements. These policies have seen mixed results. Currently, just 66% of California high schools require more than the minimum two years of math mandated by the state for graduation (Gao, 2021). In her policy brief studying the impact of raising California high school graduation requirements on student outcomes, Gao (2021) recommends that schools raise math-based graduation requirements to three years to match the minimum threshold for applying to a four-year college.

Requiring at least three years of math for high school graduation is associated with a 12% increase in enrollment in advanced math courses beyond Algebra 2 and a 6% increase in A-G completion rate. A concern among district leaders is that requiring more math for graduation could lead to fewer students graduating if the math becomes too challenging. Gao's (2021) findings show this concern is unfounded, as higher math graduation requirements were not associated with significant changes in dropout rate.

In addition to potentially aligning high school math graduation requirements with four-year college entry requirements, Mazzeo (2010) hypothesized that the policy change of the Chicago public schools mandating advanced coursework for graduation would increase the racial diversity of who takes those courses. Nearly all enrollment-based racial, socioeconomic, and special education status disproportionalities were eliminated after policy changes that mandated certain advanced courses for graduation. However, these successes were tempered by data showing that failure rates increased while GPAs, college enrollment, and graduation rates all declined for many students after the policy change. In reflecting on the gains in advanced course-taking and why they did not translate into improved academic outcomes for historically underserved student populations, the Chicago public school study suggested two policy implementations: building the capacity of school leaders to improve instruction by a focus on pedagogy, instead of a focus simply on curriculum/course requirements; and improved professional development to ensure that all teachers have effective strategies to support all students to maintain a high level of engagement in their classes (Mazzeo, 2010). Despite these policy recommendations, this comprehensive study of changing graduation requirements to mandate more academically rigorous classes for all students found that course-taking mandates were not sufficient to affect outcomes beyond enrollment numbers.

Opportunities to Raise Grades in Classes Required for College Admission

Mazzeo's (2010) study of Chicago public high schools found no differences by race in the impact of the policy to increase graduation requirements to include more rigorous courses. Gutiérrez's (2000) case study of a Maryland urban high school math department found that there are ways to structure math department and their leadership to significantly improve African American student achievement in advanced math courses. When a math department chairperson instilled specific elements department-wide, African American students took more math classes and high levels of math (Gutiérrez, 2000). Achieving these outcomes involved limiting the number of lower-level math courses; keeping graduation requirements to at least three years of math so that all students took courses through Algebra 2; regularly rotating teachers' schedules to create an atmosphere where all teachers feel a collective responsibility to the all students' learning; and providing summer Algebra 1 and Geometry courses so students who failed a semester had the opportunity to make it up and move onto the next course in the fall. The credit recovery option in the studied Maryland school was unique, as students who failed the first semester of Algebra 1 or Geometry were able to retake it during second semester and had the option to gain second-semester credit that same summer.

The Role of School Counselors

While altering course placement policy yielded mixed results in reducing unequal access to higher-level math, there is clearer evidence that school counselors can play a role in reducing—or exacerbating—inequalities (Kusko, 2020; Lee & Ekstrom, 1987; Sciarra, 2010). Using a national data set of nearly 10,000 public high school students, Lee and Ekstrom (1987) studied how access to guidance counselors affected the number of math courses students took in high school, focusing on early ninth grade "program/track" counseling and 11th/12th grade

"career/college" counseling. They focused on math course-taking because math is the high school subject most linked to future achievement in higher education and job earnings. Findings included that counselors had a limited influence on students' "program/track" selection at the beginning of high school and that only about half of high school students had access to a counselor for college advising and career advising. They also found that students without regular access to or relationships with guidance counselors in high school took fewer math courses.

Sciarra's (2010) study of whether high school seniors took advanced math relied on the nearly 12,000 high school seniors from the Educational Longitudinal Study of 2002–2004.His study concludes that school counselors have a responsibility to proactively work with students to overcome these barriers of taking four years of math. Although school counselors may influence students' math pathway decisions, they do not always make course pathway suggestions equitably. In their survey of college students in the Los Angeles area, Smith Arrillaga et al. (2023) found that Asian Americans received recommendations from high school counselors to take Calculus at the highest rate of any racial group (61%) while the African American students surveyed only received a Calculus recommendation from counselors 36% of the time. In this same survey, 60% of non-first-generation college students felt taking Calculus in high school improved one's chance of getting into a selective college, compared to 40% of first-generation students agreeing with this statement. Although there is mixed evidence on how much of a factor high school calculus has over the college admission process (Harvard University, 2023), these data illuminate the significance of counselor influence on students' course-taking decisions, particularly for first-generation students or others who may not have family at home who know the college-going process well enough to give advice. Sciarra (2010) recommended that high school counselors work individually with students who are intending to pursue a

bachelor's degree but are not intending to enroll in advanced math in high school in order to ensure they are knowledgeable about math's importance.

The recommendation that school counselors take a proactive role in helping students understand that advanced high school math opens future opportunities is further developed by Kusko's (2020) qualitative study on factors leading to students' success in AP classes in a Southern California high school. Kusko (2020) found that counselors can be influential in raising students' awareness of the placement process into APs, conveying why taking APs is valuable, and supporting students in AP success. This influence can be positive or negative, depending on counselors' own biases and a school's policy of how seats in AP classes are allocated—especially when there are more students interested in taking a course than there are seats available.

To sum up, there are many institutional factors out of students' control that influence whether they take advanced math in high school. Some of the most impactful and common factors include course placement and tracking policies, high school graduation requirements, four-year college admission requirements, department-wide opportunities to raise grades in college required courses, and the role of school academic counselors. Policies around these factors are determined by school and district leaders. Ultimately, any of these institutional factors—as well as social factors, such as historical family success in high school and college—can exacerbate or attenuate inequalities on who has access to advanced math classes. Institutional factors do not influence students in a vacuum; they have permeable borders of influence which constantly interact with other factors.

Classroom Factors Influencing Why Students Do Not Take Four Years of Math

Although certain institutional policies are shaped by district and school leaders, math teachers also have significant influence over whether high school students ultimately take advanced math their senior year. Four significant classroom factors are: teachers fostering students' sense of belonging, high quality instruction, multiple opportunities for students to demonstrate mastery of content, and opportunities for credit recovery when getting a D or an F in any high school math class. Math teachers have the most significant influence over each of these factors, and their intentionality towards implementing them affects how many math courses students take in high school and how prepared they are to continue in math.

Math Teachers Fostering Students' Sense of Belonging

Fostering students' sense of belonging in math class is a significant factor influencing students to continue to take math classes in high school beyond those which are required for graduation. An international study using 2015 Trends in International Mathematics and Science Study (TIMSS) data found a strong positive correlation with students' sense of belonging in advanced math class and students' attitudes towards math class (Smith et al., 2021, p. 6). Boaler and Greeno (2000) interviewed high school calculus students and provided a counterargument to the notion that high school mathematics simply becomes too rigorous for some students. Instead, they use a theoretical framework termed figured world, developed by Holland et al. (1998) to explain why some advanced math students decide to stop taking math. The traditional structure or figured worlds of advanced math classrooms are so narrow and rules-bound that many students decide that math is not for them, as this type of learning conflicts with their developing identity and need for self-agency in school (Boaler & Greeno, 2000).

Boaler and Greeno's (2000) qualitative study on belonging in math class is unique as they only interviewed high school students taking calculus. Since all interviewed students were taking college-level math classes in high school, they all had years of success in math. However, two key themes emerged differentiating students who liked math class and intended to continue after high school from those who were unsure. Traditional classroom teaching styles where learning was individualistic, with the teacher lecturing and showing how to do problem types followed by students practicing taught skills with little discussion, were defined as didactic teaching. This lecture-based pedagogy was contrasted with discussion-based teaching, here students were active participants in class, connecting their individual learning in collaborative ways with each other and the teacher. Many students in the "discussion-based teaching" classrooms described the class environment as familial.

In both these teaching styles, many students did well. However, in their data analysis, Boaler and Greeno (2000) found key differences among students who were struggling. Of the 48 calculus students who were interviewed, 32 were taught in didactic classrooms and 16 in discussion-based classrooms. In the didactic classrooms, only 50% of students reported a positive association with math class compared to a 95% positive association in the discussion-based classrooms. For students in the didactic classrooms, the most common reason for becoming uninterested in mathematics was to pursue subjects that offered opportunities for expression, interpretation and agency. Overall, of the interviewed students who reported that they were not planning to take math beyond high school calculus, 94% were in didactic classrooms.

Interviewing students in math classes about their sense of purpose and future plans in math is important. However, a limitation of Boaler and Greeno's (2000) study was that they only studied whether high school students *intended* to continue in math after high school. As their

study was not longitudinal, they did not study whether students actually pursued math in subsequent years. Though didactic students liked math less, it may be that they continued as they had been successful in it, as evidenced by those students taking a college level math class in high school. Nevertheless, these results suggest teachers' use of discussion-based teaching to develop students' mathematical identities could support increased math course-taking.

High-Quality Math Instruction

High-quality instruction affects learning, intersecting teachers' ability to foster a sense of belonging with pedagogy to create the conditions where all students can learn math. Math instruction should be defined far more broadly than simply what math tasks or curricula are used in the classroom (Ball, 2018; Krall, 2018; Schoenfeld, 2018; Seda & Brown, 2021). Numerous researchers have created frameworks to analyze the factors that comprise high-quality teaching and learning. Schoenfeld's (2018) TRU (Teaching for Robust Understanding) math framework dives deeply into how teachers create opportunities for students' ongoing engagement with mathematics. He identifies the dimensions of powerful classrooms that are established and maintained by a teacher's pedagogy: (1) The content; (2) Cognitive demand; (3) Equitable access to content; (4) Agency, ownership and identity; and (5) Formative Assessment. The TRU framework shifts the focus on quality instruction away from what the teacher is doing and instead to what students are experiencing while learning the mathematics.

While the TRU Math framework focuses on the elements teachers should consider throughout their entire math program, a theme of Deborah Ball's Presidential Address at the 2018 American Educational Research Association's annual meeting was the power of teachers' decisions in discretionary spaces in mathematics classrooms (Ball, 2018). She explained that while teaching, math teachers make approximately 1,200 to 1,500 micro-decisions per day, and

that these decisions, termed discretionary spaces, are where they have the greatest power to shape success in math class. Similarly, in his comprehensive guide of the necessary conditions needed for students' success in secondary math classrooms, Krall (2018) provides a model for secondary pedagogy which aligns the intersection of three conditions: (1) Academic Safety; (2) Effective facilitation; and (3) Quality tasks. All three of these frameworks address the intersection of *what* teachers teach and *how* they teach to ensure that all students are engaged in mathematics and feel part of a community of learners.

In their framework for equity in math classrooms, Seda and Brown (2021) identify seven critical factors in high-quality mathematics instruction which is culturally responsive and leads to both academic success and all students seeing themselves as capable of pursuing advanced mathematics. This framework examines the intersection of high-quality instruction in mathematics and more equitable outcomes for students from historically underrepresented groups. There are seven components to this pedagogical framework for equity in math classrooms: (1) Include others as experts; (2) Be critically conscious; (3) Understand your students well; (4) Use culturally relevant curricula; (5) Assess, activate, and build on prior knowledge; (6) Release control; and (7) Expect more. Though these studies all agree that high-quality math instruction greatly affects who continues in advanced math classes, both Krall (2018) and Seda and Brown (2021) also argue, if differently, that specific pedagogical conditions are necessary to achieve equitable outcomes in achievement.

Multiple Opportunities for Students to Demonstrate Mastery of Content

Another factor influencing students' success and trajectory in math is when teachers provide students with multiple opportunities to demonstrate mastery of the content. Gutiérrez's (2000) study of a Maryland school which had high rates of African American students taking

advanced math found that having ongoing tutoring opportunities from classroom teachers, including evenings and weekends, were a critical factor in students' success. Teachers regularly tutoring their students not only supported their math knowledge, but also built-up students' self-image as capable of success in these courses. Teachers serving this dual role was a significant finding of Gutierrez's (2000) case study.

Another factor leading to the success of these African American students in advanced math classes was a classroom policy allowing test retakes and alternative ways for students to demonstrate what they have learned (Gutiérrez, 2000). Over the past several years, many California schools have been incorporating professional development from Joe Feldman's Grading for Equity framework which proposes, among other things, that grading practices are less influenced by implicit bias and more focused on learning when students are giving multiple opportunities throughout a grading period to demonstrate mastery on any given topic (Feldman, 2018).

Recently, this clause of Feldman's (2018) Grading for Equity framework was applied in Curley and Downey's (2023) study of an advanced statistics course at two small liberal arts colleges. Despite challenges in implementing an entirely new approach to grading, Curley and Downey (2023) found that students were both more engaged and more prepared at the end of the course, and that those who did struggle were identified far earlier in first semester. Supports and adjustments by the professor in what was taught were more successful throughout second semester as a result.

Ongoing tutoring opportunities and classroom policies for test retakes would benefit English Language learners in particular, who are simultaneously learning math and English when in math class. Students who are designated English Language Learners (ELLs) are required to

use one of their electives each year to take an English language development (ELD) class at their designated English proficiency level (California Department of Education, 2019). Certain California schools offer either bilingual math classes (taught in a student's native language when there is a majority-language spoken by the student population) or sheltered math classes where the entire class is made up of ELL students taught by a teacher with a specialization in supporting language development of ELLs. Both types of classes are considered ELD classes and termed "integrated ELD" (California Department of Education, 2019).

In his quantitative study of whether seniors took advanced math in high school, Sciarra (2010) found that ELLs required to take a designated ELD class at their level were less likely to take advanced math classes because they did not have room in their schedule. Conversely, ELLs who attended schools which offered bilingual or sheltered math classes were more likely to take advanced math as they did not have to give up an elective for their ELD class (Sciarra, 2010). Although ELL students are only one example of a sub-populations' unique scheduling needs, their experience provides a clear example of the importance for all students in having multiple opportunities to demonstrate content mastery.

Opportunities for Credit Recovery when Receiving a D or F in a Math Class

While accessibility to the language of math—whether in English or a student's native language—impacts students' ability to succeed, those who receive a D or F in a math class both lose A-G eligibility. Furthermore, students receiving an F must repeat it the following school year. These students often lose the possibility of taking advanced math in 12th grade because they simply run out of time. Schools which provide students who have received a D or F in math with opportunities to retake it without losing a year of progress leave the possibility of reaching advanced math courses open in their senior year. Common ways to do this include offering

summer school to recover a year's worth of credit and allowing students to concurrently enroll in two math classes the following school year in lieu of an elective.

Fong et al. (2014) found that when California students repeat Algebra 1 the following school year, positive gains in standardized test scores result. Notably, this study was conducted in an era when high school students took state standardized tests annually. Under current state testing laws (2024), high school students only test when juniors, this delay in state testing make it hard to know if their standardized test scores rise after repeating Algebra 1, since this most commonly happens from ninth to tenth grade.

In their research within Chicago Public Schools, Rickles et al. (2018) studied students who had failed Algebra 1 and compared outcomes of those who did a summer online credit recovery class with those who completed an in-person summer school class. Online credit recovery classes lead to greater increases in graduation rates than in-person summer school classes, although students did not learn as much as when they are in person with a teacher (Viano & Henry, 2023). In Rickles et al.'s (2018) study, students were randomly assigned to a credit recovery teaching methodology. Surprisingly, they found that while students learned more in the in-person class, there was no difference in the future amount of math credits students earned from either online or in-person credit recovery. This said, students who failed Algebra 1 and later were able to earn that course credit still had a far lower mean number of overall math credits taken over four years of high school: students earning a C or higher in Algebra 1 amassed 6.6 semesters of math credit on average, compared against 4.8 semesters of credit for students failing Algebra 1.In other words, while offering credit recovery options for students who received a D or F in a math course allowed them to continue onto the next level of math, Rickles et al. (2018) found

that students who failed Algebra 1 still only took between two and three years of math in high school on average.

Though credit recovery options offer students increased points of entry toward taking more advanced math, there is no existing data to suggest that making up that credit leads to more students taking four years of math. In their study of over 300,000 students in Florida, Hart et al. (2019) found that online credit recovery classes in any subject had a positive correlation with students taking and passing the next subsequent class; this said, their study did not look specifically at math classes. While there is compelling evidence that credit recovery options in math increase high school graduation rates (Hart et al., 2019; Heinrich & Darling-Aduana, 2021; Rickles et al., 2018; Viano & Henry, 2020; Viano & Henry, 2023), students who fail a math class—particularly near the beginning of high school—are generally not successfully progressing through the more advanced coursework.

Individual Factors Influencing Why Students Do Not Take Four Years of Math

While school leaders and math teachers have direct influence over institutional and classroom policy decisions, the final set of factors affecting whether a student takes advanced math in 12th grade are grounded in the individual student. This said, many of these individual factors are not within the direct control of a student. In her Presidential Address to the American Educational Research Association, Ball (2018) explained how a student's experience in a math classroom is influenced by their environment and that both the classroom and the larger environment around the student has permeable walls where endless factors interact to influence student learning. These environments are unique to each student. There are no definitive categories that describe what these factors are, but some examples of factors that have been more often studied include a student's self-perception about their ability to do well in an advanced

math class and its correlation to future goals, the influence of family and peers, and how well students did in prior math courses.

Student Self-Perception: "Can I Do It? Do I Want to Do It?"

The Eccles (1983) Expectancy-Value Model provides a nuanced view of the factors which may influence a student's decision to take a fourth year of math. The Expectancy-Value Model is reflected by how a student answers two questions: "Can I do it?" and "Do I want to do it?" (Eccles & Wigfield, 2002, as cited in Thompson, 2017). This model investigates competencies that students evaluate in themselves when making decisions: "attainment value or importance, intrinsic value, utility value or usefulness of the task, and cost" (Eccles et al., 1983, as cited in Wigfield & Eccles, 2000, p. 72).

Attainment value is defined as how much value a student places on doing well on a task (Eccles et al., 1983). Applied to the choice over taking math in 12th grade, this theory would predict that one aspect of students' decision-making would be their perception of how well they would do in that math class. Many factors could contribute to that perception, including how well they did in the previous math class, access to outside help, and family support.

Intrinsic value is defined by how much a student enjoys a task (Eccles et al., 1983). Intrinsic value may influence 12th grade math-taking based on how much they enjoy doing math. Intrinsic value is constructed in similar ways to attainment value: how well a student has done in previous math classes, what positive experiences a student has had with math both inside and outside of school, and what their family's attitude towards math has been.

Utility value is how much a student sees a school task as useful in relation to their current or future goals (Eccles et al., 1983). Utility value can be high for math course-taking, as many

students and families see math performance as demonstrating smartness and math courses as necessary for college applications and/or as pathways to higher paying jobs.

Finally, cost is defined as the effort it would take to be successful at a task and what other opportunities a student gives up by choosing that task (Eccles et al., 1983). This aspect of the Expectancy-Value Model most relates to issues around what other 12th grade courses a student needs to graduate and/or be eligible for four-year colleges. Many students simply do not have space in their senior year schedule for an optional math class due to other unmet requirements.

Each of the Eccles and Wigfield (2002) competencies are intertwined in the complexities of why students do or do not take math in 12th grade. Master schedule limitations, which happen early in a student's high school career, often have an indirect impact. For example, a student who could not fit Spanish 1 into their schedule in ninth grade may have been counseled to simply take a second elective that year. However, by senior year, that student may prioritize taking a third year of Spanish and not even consider taking advanced math if they have already met the three-year A-G math requirement. By senior year, when students have room for only a third year of Spanish or a fourth year of math, each of Eccles and Wigfield's (2002) four competencies regarding both subjects, relative to one another, would affect their course-taking decision.

Similar to the Eccles and Wigfield (2002) theme of "Do I want to do it?," Domina et al. (2011) set out to test whether students' college expectations influenced the importance they placed on high school mathematics. Beginning in 2004, the California Motivation Project was a longitudinal study over three years, using survey data from grades seven to 12 in six schools in a Southern California district combined with the Educational Longitudinal Study of 2002 (Domina et al., 2011). Their results demonstrated a statistically significant positive correlation between students' expectations of going to college and their perceptions of the usefulness of advanced

high school math courses. Additionally, they found students who expected to go to college perceived the utility of advanced high school math to be twice as large as their measured intrinsic interest in the math itself. In this case, students' desire and perception that they would attend a four-year university factored into decision-making around taking more high school math courses.

Sciarra (2010) likewise found a positive correlation between students who expected to receive a bachelor's degree and taking high school math courses beyond Algebra 2. However, despite this positive correlation, he found that White and Asian students who intended to pursue a bachelor's degree were more likely to be enrolled in math classes beyond Algebra 2 than students of other races.

Influence of Family and Peers

In addition to high school students' perceptions on whether they will attend a four-year college, their family and social groups also impact their decision-making around taking advanced math in high school (Gottfried et al., 2017; Ozturk & Singh, 2006; Yildirim, 2019). Gottfried et al. (2017) completed a literature review of 11 studies using large-scale data sets from 2001 to 2015 to understand the influence of friends and family on high school students' decision-making in advanced math and science course-taking. This study found that friends exerted the strongest influence 10th to 12th grades, where students with friends with high academic values—particularly those with positive attitudes about math—were more likely to take advanced math and science courses in high school. They also found that a student's parents had a stronger influence than friends, especially when parents had high expectations for homework completion, could provide homework help for math and science coursework, and understood school course-taking policies in math and science.

That families held a strong influence over students' advanced math course-taking and post-high school plans was also found in Ozturk and Singh's (2006) study on how students' socio-economic status and previous math achievement affected advanced math course-taking. They investigated discrimination in advanced math course placement based on socioeconomic status and, relatedly, whether students successful in one math course automatically enrolled in the next one. To isolate variables, they selected students for their study who met all of the following criteria: general education public school students who stayed in the same school for all of high school; students eligible to graduate with just two years of math; and students whose schools offered multiple years of advanced math beyond Algebra 2.They found that a family's socioeconomic status alone did not predict math achievement, but that there was a high positive correlation between parental expectations and students' decisions in two domains: whether to take advanced math courses and goals for their post-high school plans. Ozturk and Singh (2006) thus concluded that students tend to identify with and internalize their parents' goals for their future. Furthermore, they found that success in a math class was strongly correlated with taking the next math class in a high school sequence beyond the two-year graduation requirement.

Families' and peers' opinions over high school math course-taking significantly influenced those decisions among students (Kevelson et al., 2023; Ozturk & Singh, 2006; Sciarra, 2010). The findings from Kevelson et al.'s (2023) study using high school enrollment in college-level courses as its dependent variable—along with Sciarra's (2010) study over whether or not seniors enrolled in advanced math—support the notion that perceptions held by students, peers, and families about the importance of math and attending college had a significant influence over whether students took math in senior year. Student demographics were found to be a far weaker predictor of students' college-level course-taking in high school than parent and

peer influence (Kevelson et al., 2023), once again demonstrating the importance of social influence on math-taking outcomes.

Similar to differences among racial groups in whether college-going students took math in 12th grade, Sciarra (2010) found differences between racial groups in the predictive influence of parents' expectations for their child to receive a bachelor's degree. Kevelson et al. (2023) found that students whose families were involved in students' course-taking decisions and future college plans were almost twice as likely to complete a college-level course in high school than those whose families did not have these conversations. Although Kevelson et al.'s (2023) finding were for all classes and not just math classes, this nevertheless supports Sciarra's (2010) findings about the positive correlation between family and peer expectations in advanced math course-taking.

Prior Math Achievement

While perceptions among students, peers, and families about the importance of attending college predicts advanced math course-taking in high school, another strong predictor is math achievement in early high school courses (Kelvelson, 2023; Lee & Ekstrom, 1987; Sciarra, 2010). Differences between background variables such as race and ethnicity, socioeconomic status and parent education level are reduced or eliminated when students' math achievement scores (measured by 10th grade semester grades) and overall achievement (as measured by 10th grade GPA) are at or above grade level (Sciarra, 2010). Similarly, Kevelson et al. (2023) found that ninth grade math achievement (regardless of what course was taken) was the greatest predictor of who took college-level math courses in high school. Their study included three types of college-credit courses: Advanced Placement (AP), International Baccalaureate (IB), and dual enrollment, where a student takes a community college course during high school. As Kevelson

et al. (2023) did not specify which math course their ninth graders were taking, it is impossible to analyze the specific role that tracking in math class placement played in these results. A second limitation of this study is that ninth grade math achievement as an independent variable was only measured through ninth grade math scores. As such, ninth grade achievement in other courses required for graduation could have been equally predictive for later college-level course-taking outcomes.

Conclusion

This literature review explored factors supporting and preventing California high school students from taking a fourth year of math in high school, including: what is currently known about who is and is not taking four years of high school math; the short- and long-term value in taking more math in high school; and the institutional, classroom-based, and individual factors supporting or limiting high school students' desire and ability to take a fourth year of math. After lengthy study, the California State University Board of Trustees voted in January 2023 to not add a fourth year of high school math to its admission requirements. Its rationale was that doing so would cause more harm than good in admission by excluding even more students from applying to California's public universities directly after high school (Smith Arrillaga, 2023). Since individual California districts still retain the ability to raise the number of years of math required beyond the two-year state minimum, this recent state-wide policy decision means that Thompson's (2017) conceptual framework on three math course-taking ecologies—institutional factors, classroom factors, and individual factors—remains an important topic to research, particularly as it may motivate individual districts to invest in math support for California high school students.

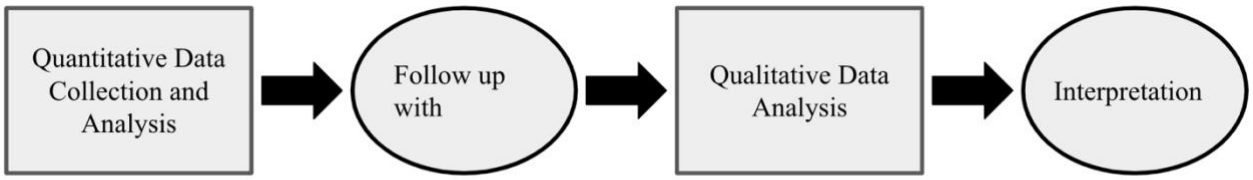
CHAPTER 4: METHODOLOGY

Introduction

This study will use an explanatory sequential mixed-methods approach to explore high school seniors' decision-making around enrollment in a fourth year of math at a large, comprehensive public high school. My analysis first included site-level descriptive statistics, followed by a mixed-methods survey of all 12th graders to understand math course-taking decision-making. Creswell (2014) defines an explanatory sequential mixed-methods approach as when initial quantitative data can be used to explain and deepen the understanding gained from later qualitative data, as shown in Figure 4 below:

Figure 4

Explanatory Sequential Mixed Methods



(Creswell, 2014, p. 220)

My overarching research question is: What patterns and inequalities can be observed in math course-taking among seniors at a high performing, diverse high school? I explore various sub-questions, first through an analysis of site-level descriptive statistics and, second, through a mixed methods survey given to all seniors at Waterview High School.

Phase one of my research answers the sub-question: *What are the patterns in 4th year math enrollment by demographics and prior academic achievement at a high performing, diverse, suburban high school.* The purpose of this phase of research was to collect and analyze site-level

descriptive statistics on course-taking patterns for all four years of high school among seniors graduating in 2024 at Waterview High. Quantitative data for this portion of my study was pulled from district-wide databases Illuminate, Schoolzilla, and Aeries. These data were collected in collaboration with the district's Senior Manager of Data, Assessment and Research.

Phase two of my research answers two sub-questions: (1) How do seniors explain what prevented or facilitated their decision to enroll or not enroll in math their senior year? and (2) How do seniors perceive their experiences in math classes and the importance of taking advanced math classes in high school? The purpose of this phase of research is to gain the perspectives of these students on their own decision-making with respect to math enrollment and to further illuminate the inequalities in math course-taking patterns. Quantitative and qualitative data for this portion of my study was gathered through a survey given to all 12th graders during fall of their senior year (2023) at Waterview High School.

Setting/Context

The setting for this study is Waterview High School in Northern California. Drawing on state-wide data from Reed et al.'s (2023b) descriptive statistics on math course-taking in California, this study will compare those statewide findings on 12th grade math course-taking to student-level data from Waterview High School. Waterview High is a comprehensive, suburban Bay Area High School. Schoolwide demographics are shown in Table 1.

Table 1

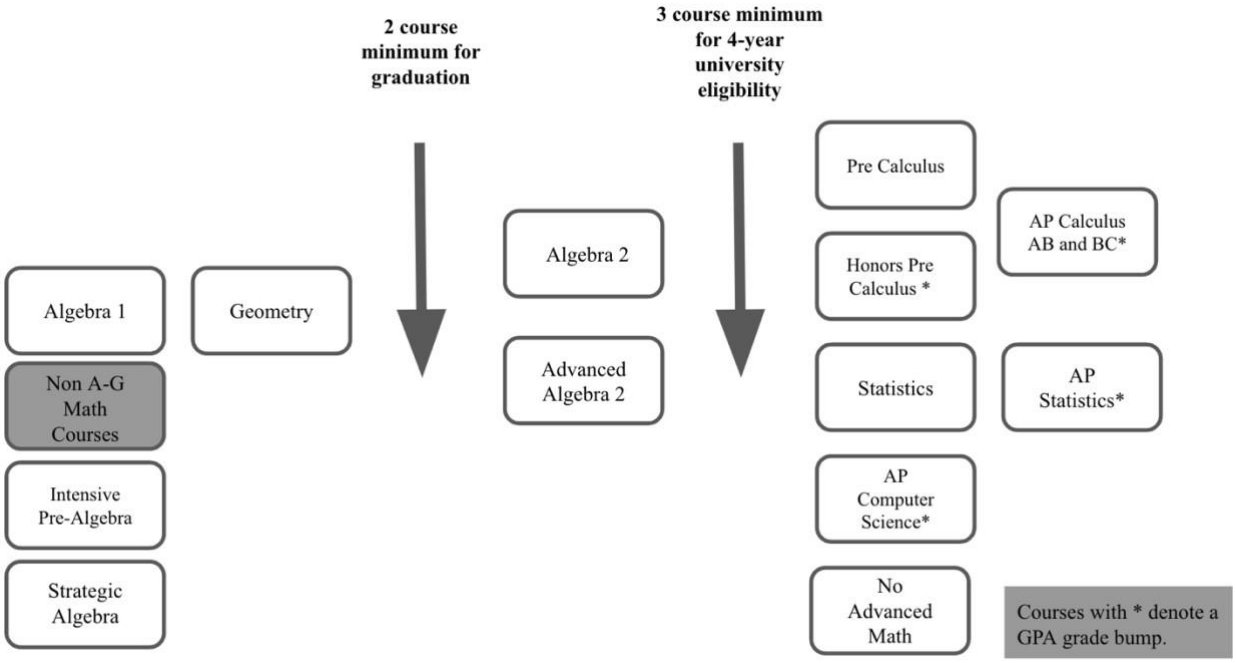
Waterview High Schoolwide Demographics Compared to California (Reed, 2021)

	Waterview High Enrollment		Typical CA Suburban District Demographics	California Demographics
Race/ Ethnicity	Total Enrollment	% of Students	Percent	Percent
American Indian/ Alaskan Native	3	0.2%	<1%	<1%
Asian	545	29.5%	10%	12%
Black/ African American	77	4.2%	5%	5%
Hispanic/ Latinx	315	17.0%	52%	56%
Intentionally Left Blank/ Other	16	0.9%	2%	n/a
Multi-Racial	340	18.4%	4%	5%
Pacific Islander	6	0.3%	3%	<1%
White	548	29.6%	24%	21%
Total	1850	100.0%	100%	100%

Racial demographic composition at Waterview High is similar to that at many California high schools. Students at Waterview High School are required to complete just two years of math for graduation. It is also known as a highly academic high school because of its high rates of students taking honors and AP classes. Certain math courses are tracked, with a regular and advanced track. After taking Algebra 2, students have two choices of pathways. According to Schoolzilla, the Waterview High School district database, in Spring of 2023, over 33% of students took at least one AP exam. All options for math course-taking at Waterview High are illustrated in Figure 5.

Figure 5

Math Course-Taking Pathways at Waterview High



Despite its strong academic reputation and two distinct four-year math pathways, Black and Latinx students enroll at low levels in advanced math courses among 12th graders at Waterview High. These demographic disproportionalities are discussed at more length in the Literature Review.

Participants/Data Source

I conducted my research at Waterview High School for three reasons. Firstly, as Assistant Principal of Waterview High, I am familiar with the student body, teachers, and administration processes, giving me a unique degree of insight into the obstacles and supports to advanced math

class uptake among Waterview High senior students. Secondly, I chose Waterview High because it shares many characteristics with suburban schools across the state. For example, course pathway tracking begins in middle school; about 50% of incoming ninth graders took Algebra 1 in eighth grade; and Black and Latinx achievement in math is disproportionately low compared with their White and Asian counterparts. These disproportionalities exist amidst a school-wide culture described as academic and a very explicit district-wide equity focus on Black and Latinx students. In the 2021–2022 school year, 59% of Black and 48% of Latinx 12th graders met their A-G requirements to attend a four-year college, compared to 76% of White and 83% of Asian students (California Department of Education, n.d.). Waterview High reflects characteristics generalizable to many suburban California high schools (Reed, 2021). Finally, and most importantly, I conducted my research there because as a school leader, I can ensure that my findings influence both my school and district decision-making to positively impact change.

Research Design/Procedure

This mixed-methods study had two sequential phases of data collection. The first phase of data collection—site level data—included all 2023–2024 12th graders at Waterview High: 455 students. Here I rely on administrative data to describe Waterview students' math course-taking patterns and how those patterns differ depending on different demographic characteristics. In Phase 2, I explored potential explanations for those patterns via a survey of seniors.

Phase 1: Administrative Data

I had access to this existing district-level data through my professional role as Assistant Principal at Waterview High and obtained permission to analyze it from the Senior Manager of Data, Assessment and Research and Associate Superintendent of Human Resources in the

Waterview Unified School district. These data are from students in the 12th grade during the 2023–2024 school year.

This administrative data was analyzed and organized using the same math course sequential flow chart from Figure 5. For example, I examined the percentage of students who took Algebra 1 in ninth grade and examined what math courses this cohort took from 10th to 12th grades. I analyzed these trajectories by demographic characteristics.

A second analysis mimicked the data groupings from Wainstein et al.'s (2023) study of math course-taking patterns in the Los Angeles Unified School District. Specifically, I grouped the data of all 2023–2024 12th graders into three categories:

- **Group 1**—Needed to take math in 12th grade to graduate
- **Group 2**—Needed to take math in 12th grade to complete A-Gs
- **Group 3**—Completed A-G math requirements in 11th grade and took more advanced math senior year

Phase 2: Survey of Seniors

Data Collection. The second phase of data collection took the form of a mixed-methods survey of the 458 seniors at Waterview High School. This survey was developed as the by-product of department-wide work I have been leading over the past two years, some of which is analyzed in this study.

During the 2022–2023 school year, one of my professional roles was to lead school-wide professional development throughout the year once a week after school when students have an early dismissal. With leadership coaching support from Lead by Learning through Northeastern University, I designed collaborative staff inquiry groups focused on our school goals—specifically, increasing A-G eligibility for our Black students and decreasing their chronic

absences. One of the math department's collaborative inquiry groups was comprised of three teachers who did a book study of Liljedhal's (2020) work on redesigning pedagogy and layout of math classrooms to promote regular student-led group work on math problems with real-world connections, done on vertical white boards around the room. The goal of their book study was to redesign how Algebra 2 is taught in the hopes that more students—specifically Black and Latinx students underrepresented in advanced math classes—will take math beyond Algebra 2.

At Waterview High, the math department collaborative inquiry group implemented these changes in the 2023–2024 school year. Together, these teachers and I co-designed an 11th and 12th grade survey, to administer in Fall 2023 in order to have more data to inform how our school can rethink our math pathways, how we support struggling students, and how guidance is given for course selection. Having these data in Fall 2023 informed our Algebra 2 redesign and the 1:1 meetings that our counselors had with ninth to 11th grade students on course selection beginning in Winter 2024. Because the data from this survey would be used for instructional improvement with the entire math department, I was able to collect these data through my professional role. The survey was written with input from the math department and under guidance of my dissertation advisor. My survey questions are grounded in theory and rely on previous research reviewed above. For this dissertation, only the 12th grade data will be analyzed.

Survey Design. The goal of the survey was to better understand seniors' thought process when choosing whether and what math classes to take each year. I was interested in students' motivation for their choice of math classes, and the institutional, classroom and individual factors that influenced those decisions (Kurlaender & Hibel, 2018, Thompson, 2017).

My initial process in designing the survey involved collaborating with all ten Waterview High math teachers at a department meeting to ensure that the survey would provide information

that could allow the department to encourage more juniors to take math senior year. Although my dissertation research is limited to seniors, the math department chose to administer the survey to both juniors and seniors to learn more about students who had not yet made all of their high school math course-taking decisions.

Following Thompson's (2017) framework outlined above, this study's mixed-methods survey was divided into three sections: institutional factors, classroom factors, and individual factors. Questions were drawn from prior research surveys on course tracking, graduation requirements, opportunities to raise math grades, role of counselors, sense of belonging, desire to do well in math, expectations for post-high school graduation, and family and peer influence on math course pathway decisions (Cribbs et al., 2015; Good et al., 2012; Navarette, 2021; Ozturk & Singh, 2006; Simpkins et al., 2006). Additionally, many of the survey questions were designed to ask about specific institutional and classroom factors that Waterview High School actually offers. For example, counselors visit English classes to assist with course selection at each grade level and have a process to have 1:1 meetings with any student who desires more specific advice before choosing next year's classes. Additionally, all math teachers have a test re-take policy and the school offers a robust set of classes online to use to make up credits from earning a D or an F in a previous course. A copy of the survey instrument is found in Appendix 1.

The survey was constructed using Google Forms, a tool familiar to students. Each page of the survey featured images of Waterview High and photos from former graduations to ensure that the survey felt personal. The survey was designed to take an average of 10 minutes. This structure bore student attention spans in mind while also providing time and space to invite thoughtful, open-ended responses. It incorporated feedback from the math department to more closely resemble a teacher-written survey. The survey asked two to three questions per page. All

questions were required so that students could not scroll ahead and get overwhelmed with the total number of questions on the survey. Demographic questions were included only at the end of the survey so that survey results felt completely anonymous throughout. Open-ended questions were peppered throughout the survey so students would not run out of stamina and leave them blank upon encountering them at survey's end. Question formats alternated between straightforward factual questions, questions about the importance of issues (answers were evaluated using a Likert scale), and open-ended questions within each topic/section of the survey.

The survey's anonymity offered limitations, as it meant the data could not be grouped into the same three categories (Wainstein et al., 2023) for 12th grade math course-taking as the quantitative site-level administrative data can be. These three categories which will be expanded upon in the findings are: students who minimally met graduation requirements and whose final course was Geometry; students who minimally met A-G requirements and whose final course was Algebra 2; and students whose final course was advanced math. The site-level data were tagged to a specific student ID number, so data such as cumulative math and English GPA could be compared against course-taking patterns.

My two hypotheses about what I would learn from my data collection were: (1) That many students reporting negative experiences or who had not found success in math stopped taking math when it was no longer required for graduation and/or fulfilling A-G requirements for entry to a four-year university, and (2) that students who had been encouraged regarding the long-term value of advanced math classes beyond minimum requirements were more likely to continue in math, even if they had negative experiences or low grades.

Survey Administration. The survey was administered in November and December of 2023. Because I am the Assistant Principal at the school where I administered my survey, I was

able to use my positionality to integrate the survey into school routines. This resulted in a high participation rate. The math department decided they wanted the survey administered to all juniors and seniors and were willing to give it in their classes. There were three ways the survey was administered depending on what (if any) math class the student was enrolled in: Algebra 2 and above; Geometry or Algebra 1; and seniors not taking math class.

For Algebra 2 classes and above, the survey was given in math class by the teacher. The Google Form link was shared via Google Classroom, so it was also available to absent students. Although the math teachers did not use a script to standardize how they introduced the purpose of the survey, they agreed on key ideas for how to administer it. Every math teacher gave it as the warmup (or "do-now") in the beginning of class. Students who finished the survey before others had independent work to finish so that students who needed additional time for the survey were provided time in class. Each teacher explained that the survey was completely anonymous and not tied to what math class students were currently taking. Teachers encouraged students to be as honest as possible, assuring students that the more feedback they provided, the more the math department could learn about their strengths and areas for improvement. Students were then directed to the link in Google Classroom and asked to read the initial paragraph in Google Forms which explained the goal of the survey. One variation in survey administration was that some teachers collected names of absent students and then explicitly asked those students to do the survey, while others simply assigned it as homework for absent students. Since the daily absenteeism rate is only about 5% school-wide, this variation most likely did not have a significant impact on overall participation rates or data validity.

For Algebra 1 and Geometry courses, I went into classrooms and individually invited seniors to take the survey. I explained the purpose of the survey and asked if there was a class

period they would be open to missing in the coming week. Since there were only three seniors enrolled in these courses, this was a very straightforward aspect of survey administration. Seniors in these courses who took the survey were excused from class for the period of time we arranged for them to come to my office and take the survey.

All seniors not taking a math class were invited to take the survey during the school-wide advisory period. Advisory meets twice a week on Tuesday and Thursdays, just after lunch. I reserved a large conference room for survey administration and, in groups of 30 students, I sent passes in the morning on each advisory day. To give students the sense that this was a personal invitation and to encourage them to come, I hand-wrote each pass, explaining that the math department was hoping to survey all seniors about their experiences in math classes at Waterview High to learn about strengths and areas for improvement for future students. To incentivize students to come, I let them know that I would have snacks available, would hold a raffle for an extra graduation ticket, and would excuse their attendance for the time they were with me taking the survey. I hoped these incentives would lead to them to spend more time on the survey, providing more lengthy and descriptive open-ended responses.

Students understood that filling out the survey was optional, and some chose to remain in their advisory classes and not attend. Any students who did not attend after the first invitation were given a second invitation from me the following week. It took five weeks to complete survey administration for seniors not taking math, as our advisory was held only twice a week and on two advisory days, we had school-wide events.

Survey Eligibility All seniors not taking math were invited to take the survey, with two exceptions. First, the 15 students on independent study were not enrolled in any Waterview High classes; these students were excluded from the data. Second, the ten students in self-contained

Special Education program do not take any general education academic classes and were excluded from the data. Participation rates were high overall, but also varied for each of these three groups. Unsurprisingly, since students taking a math class of Algebra 2 or above took the survey in their math class, their participation rate was the highest. A summary of participation rates by math course is shown below in Table 2.

Table 2
Survey participation rates by math course

	Eligible Students	Surveyed Students	
	n	**n**	**%**
No Math class	97	56	57.73%
Algebra/Geometry	4	1	25.00%
Algebra 2	20	17	85.00%
Pre-Calculus	48	39	81.25%
AP Calculus	93	88	94.62%
Statistics	77	68	88.31%
AP Statistics	91	73	80.22%
Total	430	343	79.77%

Seniors who did not take the survey were either late to class, absent, in the bathroom, out of class for another reason, or were doing something else without the teacher's knowledge while the rest of the class took the survey. The overall response rate among seniors enrolled in math was 86.2% (287 of the 333 seniors taking math in the 2023–2024 school year). One aspect of the variation in participation rates by course is that certain teachers were more diligent about walking around the room while students took the survey to ensure they were on-task and of following up directly with any absent students. Additionally, certain courses such Calculus have only 1 teacher while others such as Algebra 2 have four teachers so there is less variation in courses with just one teacher.

Seniors not enrolled in a math class took the survey during advisory and had different reasons for their participation rates. Absence rates among students invited in advisory periods can be explained by several reasons, including: passes delivered to the classroom teacher of the class period before advisory may have caused the teacher to set them down and forget to pass them out; students may not have been interested in missing advisory; students may have been absent from advisory; or students may have already had a pass to visit an academic teacher during advisory time to make up a test or get extra help on an upcoming assignment. Of the 99 seniors not taking math, 56 of them (56.6%) took the survey. The overall participation rate for all 432 eligible seniors, including both those taking and not taking math, was 343, or 79.4%.

Although survey participation rates by racial category were similar to the overall demographics of Waterview High, a few variances emerged due to how the demographic questions were structured. When asked their race/ethnicity, students were purposefully not limited to choosing only one box; the question allowed multiple responses. Many students chose multiple race categories, which could reflect the racial background of their families from more than one generation removed. Similarly, students were not asked if they officially are considered an English Language Learner. Instead, they were asked if any languages other than English are spoken at home and if so, how many. The demographic information for survey participants is shown in Table 3.

Table 3

Demographic Information on Survey Participants (Self-Reported)

	Eligible Students		Surveyed Students	
	n	%	n	%
English Language Learner Status				
ELL Students	89	4.81%	69	20.10%
Race/Ethnicity				
Asian American	545	29.5%	93	27.11%
African American	77	4.2%	11	3.20%
Hispanic/Latinx	315	17.00%	28	8.20%
Multi Racial	340	18.40%	87	25.40%
White	548	29.60%	102	29.70%
Other or Declined to State	16	0.90%	22	6.40%
Total Respondents	1850	100.00%	343	100.00%

Although students could select more than one race category on the survey, participation by race was within a 1% difference compared with overall Waterview High demographics for Asian, Black, Filipino, Pacific Islander, and White students. Per students' self-reported race, Hispanic/Latinx participation in the survey was much lower (8.2%), and multi-racial participation much higher (25.4%), than was reflected in overall AHS demographics, where 17% of students were listed as Hispanic/Latinx and 18.4% were listed as multiracial. This is likely because California's racial requirements on school enrollment forms consider a multiracial student to be Hispanic/Latinx if any one race category on a student's school enrollment form is marked for that demographic. As a result, all multiracial students who have some Hispanic/Latinx heritage are considered Hispanic/Latinx (and never multiracial) by the state of California (California Department of Education, 2022b).

Data Analysis

The quantitative site-level data has been used to contextualize math course-taking patterns and inequalities, including what courses high school seniors took in math; whether students were meeting A-G requirements (particularly in math); whether students received a grade of D or F in any A-G course prior to senior year; how enrollment patterns in math differed depending on grades received in previous math classes; and in what grade students completed in Algebra 1. To answer my first research question, What are the patterns in 4th year math enrollment by demographics and prior academic achievement at a high performing, diverse suburban school?, administrative data has been organized into three categories: 1)students taking math to graduate whose final course 2)students taking math to meet their A-G eligibility requirements whose final course is Algebra 2; and 3)students taking advanced math beyond the minimum four-year university eligibility requirements.

I use emerging trends from administrative data collection to better contextualize results from student surveys. After identifying and coding themes from the qualitative survey questions, I weave them into a story highlighting inequalities by subgroups and the complex reasons behind math course-taking patterns. Data is organized by the courses 12th graders are enrolled in, grouping courses into three categories: those required for graduation (Intensive Pre-Algebra, Strategic Algebra, Algebra 1, and Geometry); those required for meeting four-year university eligibility (Algebra 2 and Advanced Algebra 2); and advanced courses (Pre-Calculus, Statistics, AP Calculus, and AP Statistics) beyond the minimum requirements. Using a combination of attribute and causation coding (Saldaña, 2013), I identify patterns and describe the influence on seniors' math course taking by institutional, classroom, and individual factors. By identifying

connections between themes (Creswell, 2014)., my results identify areas for practical and policy focus for K-12 school leaders

Positionality

I have been fascinated by course-taking decisions in math ever since I was an undergraduate taking education courses where we reflected on our educational journeys. As a second grader, I got kicked out of class frequently because the work was too easy and I would socialize excessively when I had nothing to do. Along with two of my peers, we were sent daily into the hallway to learn our times tables through the 20s as a way of keeping us busy and out of the teacher's hair. In third and fourth grades, the three of us took math with a fifth-grade teacher, and in fifth grade we walked to our local middle school to take eighth grade math. I took Algebra 1 in sixth grade, AP Calculus AB as a sophomore, Multivariable Calculus as a junior, and an independent study on differential equations as a senior—and then, for 10 years, I stopped taking math classes altogether. By senior year, I was convinced that I was terrible at math, and I never again wanted to be associated with the tiny group of nerdy white boys who took these advanced classes with me. The next time I took a math class was 10 years later when I wanted to get my single-subject credential in math to complement my multiple-subject credential as an Education student. Throughout my undergraduate and master's programs, I have reflected on what led me to quit math for so many years—and also what brought me back to it as a math teacher. I truly wanted nothing to do with it for over a decade, which is something I regret in adulthood.

This is my 24th year as a public school educator. I have worked as a bilingual elementary school Spanish teacher, a middle school math teacher, and both a district and site administrator. I strive to be the type of math teacher I now realize I needed when I was in high school: laser focused on ensuring all students believe they belong in advanced math classes and leading with a

pedagogy that treats math as a social endeavor with visual modeling. I believe that influencing who succeeds in advanced math can only be successful when teachers fundamentally change how they teach so that learning math is a more social endeavor, implement teaching methods reliant on multiple ways of approaching a problem, and constantly strive to connect math class learning to why math is important outside of school.

The purpose of critical research is to do research with people, not on people (Merriam & Tisdell, 2016). While my positionality connects my insider role leading focus groups to collective analyze data with my leadership team, I believe I understand the dual nature of this role and can handle "working the hyphen," a term used to describe this insider/outsider phenomenon (Merriam & Tisdell, 2016, p.63). I have heard the term "humanizing mathematics" used in so many contexts (Goffney, 2018; Jessup, 2021) and it is a principle I have embodied in all my roles as a math teacher and site leader. Similarly, my positionality commits me to ensuring that my qualitative data collection humanizes the phenomenon I wish to study.

The question of why some 12th graders are not taking math, and what impact our school and district staff can have on those decisions, is a question I work on daily through the multiple layers of my job. During the 2023-2024 school year, the district math task force was exploring what changes to curriculum and course pathways would result in more of our historically underrepresented minority students taking a fourth year of math in 12th grade. Two of the topics commonly discussed were: (1) What would be the consequences on 12th grade math course-taking if the district eliminated teaching Algebra 1 in eighth grade, and (2) What would be the impact of added options in our math course pathways, such as eliminating the Algebra 2 pre-requisite for our statistics course, and/or adding a Data Science course without an Algebra 2 pre-requisite?

Furthermore, I am a coauthor of a $200,000, three-year anti-bias grant issued in 2023 from the California Department of Education focusing on raising A-G attainment for historically underserved students. In Spring, 2023, I met one-on-one with every student who was receiving a D or F in Algebra 1 to ensure they understood what A-G requirements were and the importance of getting a C or higher in Algebra 1. These meetings led to a huge increase in students getting a C or higher for their semester grade in math. Although I am pulled in numerous directions as a high school Assistant Principal, this type of one-on-one work with students about math achievement is central to my core values. Apart from my dissertation research, I am regularly holding focus groups with members of our school leadership team to better understand students' course choices with the aim of increasing representation of our historically underrepresented minority students in AP classes (of all subjects).

I have ensured my research findings are trustworthy, credible, and transferable using data triangulation and member checks. An example of triangulation is having multiple people comparing findings on the same set of data (Merriam & Tisdell, 2016). Additionally, I have shared survey results with the entire math department as a member check to ensure that I have not misinterpreted students' conceptualization of critical issues in their math course-taking decisions. The goal of member checks was to ensure that my documentation of the themes that emerged from my qualitative survey question rang true with their interpretations (Merriam & Tisdell, 2016).

Limitations

As an assistant principal overseeing the math department at the school where I conducted research, I anticipated the following limitations prior to beginning my data collection. First, students could be inclined to not take the survey seriously or to go through it hastily. After

administering the survey and looking at the data, this did not appear to be a significant limitation. Having held dozens of one-on-one interviews and focus groups with students throughout my time in this job, this never became a significant issue as I always explained my core values to students, which include that I cannot influence school-wide change without first listening to the students who affected by an issue.

In limiting my study to understanding the factors that influenced students' math course-taking decisions in 12th grade, I did not include students who took four years of A-G math prior to 12th grade: for example, a student who took a summer math course to complete four years of math, took a community college math course instead of an Waterview High math course, or took AP Computer Science senior year instead of a fourth year of math.

Ethical Considerations

Because my research is simply a more formalized process of work that I am already regularly doing with students in my job, there are no major ethical considerations. I received IRB approval through my district's Senior Manager of Data, Assessment and Research and Assistant Superintendent of Human Resources. I have ensured that all data linked to students is documented with encoded ID numbers and that all qualitative data uses pseudonyms. All survey data was delivered anonymously. I explained the purpose of my research to both students and teachers to give them the chance to ask any questions about how the research will be used.

CHAPTER 5: FINDINGS ON RESEARCH QUESTION #1

Introduction

Waterview High's math course-taking patterns have some similarities to state trends, but in many ways the outcomes are far more positive than state averages. Using a combination of site-level data from multiple district databases, this analysis addresses my first research question: *What are the patterns in fourth-year math enrollment by demographic and prior academic achievement at a high performing, diverse suburban school?* To convey course-taking patterns more clearly, this analysis divides students into two groups: students who are taking math senior year and those who are not.

Data Collection and Sample

Schoolwide data on high school seniors was compiled by the Senior Manager of Data, Assessment and Research. All data encompasses 2023-2024 graduating seniors from Waterview High. Site-level data with demographic information and the current math course being taken by all seniors was pulled from the district-level report: Illuminate-Multiple Measures Report. Through a query in the district-wide student information system called Aeries, current seniors' math course records were matched to their eighth and 11th grade courses.

12th Grade Math Course-Taking Patterns

Looking at the math courses seniors are taking and who is not taking math is one way to understand math course-taking patterns. Using statewide data from California graduating seniors in 2018–2019, Reed et al. (2023b) found that approximately 25% of seniors were not taking math and 75% were not taking an advanced math course beyond Algebra 2. Table 4 illustrates Waterview High's 2023-2024 seniors' course-taking by broad mathematical categories.

Table 4

Math Course-Taking by Category

Student math course-taking decision	n	% Overall
12th graders not taking math	97	22.9%
12th graders taking math	333	77.1%
12th graders taking Algebra or Geometry	4	0.9%
12th graders taking Algebra 2	20	4.7%
12th graders taking math course above Algebra	309	71.9%

Similar to Reed et al.'s (2023b) findings, slightly less than a quarter (22.9%) of Waterview High seniors in the 2023-2024 year were not taking math. However, of Waterview High seniors who were taking math, the rates of completion of an advanced course above Algebra 2 were significantly higher than the state averages. At Waterview High, nearly 75% of all seniors were taking a math class above Algebra 2. Of the 333 seniors who were taking math, 309 or 92.8% were taking a course beyond Algebra 2. This is far above the California state average, where just 66% of seniors enrolled in a math class were taking an advanced class above Algebra 2 (Reed et al., 2023b).

Up to Algebra 2, students have no option for what math course to take as there is simply a linear progression from Algebra 1 to Geometry to Algebra 2. However, after Algebra 2, students have multiple options. Pre-Calculus, Statistics and AP Statistics all become available to students as their next course (depending on what a school offers). Table 5 shows what math courses seniors took at Waterview High in the 2023-2024 school year

Table 5

Senior Enrollment in Math Classes (N=430)

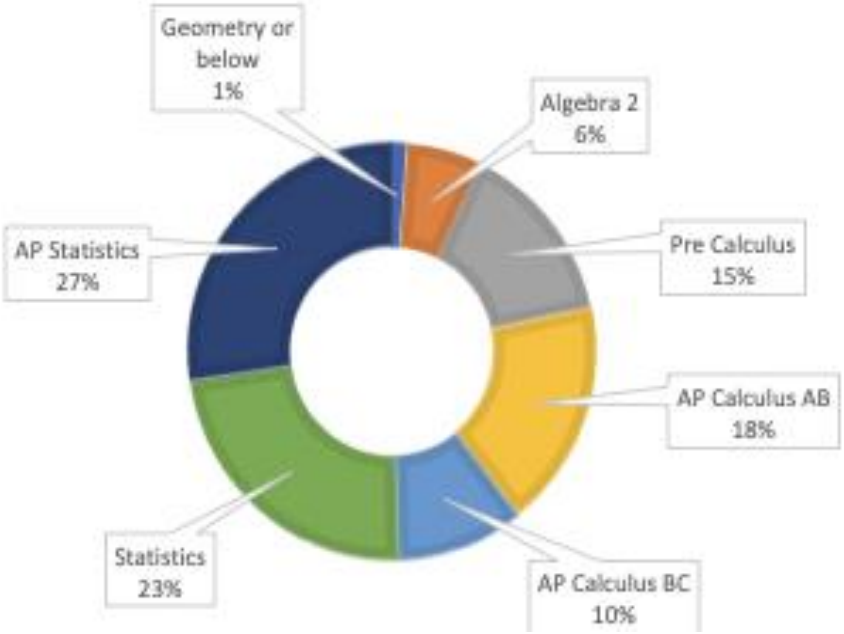
	n	% of students taking math	% of overall twelfth grade enrollment
No Math class	97	n/a	22.6%
Algebra/Geometry	4	1.2%	0.9%
Algebra 2	20	6.0%	4.7%
Pre-Calculus	48	14.4%	11.2%
AP Calculus AB	59	17.7%	13.7%
AP Calculus BC	34	10.2%	7.9%
Statistics	77	23.1%	17.9%
AP Statistics	91	27.3%	21.2%

Analysis of Students Taking Math Senior Year

Of seniors taking math in 2023–2024, half (50.4%) took the Statistics pathway and 42.3% took the Calculus pathway. This is significantly higher than statewide averages, where 16% of seniors took Statistics or AP Statistics and 38% took Pre-Calculus or Calculus in 2018–2019 (Reed et al., 2023). Subsequent chapters will analyze students' decision-making around what course they chose for senior year. Recent studies have shown that offering multiple math pathways beyond the traditional Algebra 1→Geometry→Algebra 2→Pre-Calculus→Calculus route greatly increases the diversity and amount of high school students taking advanced math (Daro & Asturias, 2019). That half of the school's seniors were enrolled in the statistics pathway has historical roots, though that history is outside the scope of this research. Math teachers and school counselors market statistics courses, which has ensured students know of its relevance to several college majors. Figure 6 below shows the course breakdown of students taking math senior year.

Figure 6

12th Grade Math Course-Taking



Racial Breakdown of Math Course-Taking

When analyzing 12th grade math course-taking trends by racial category, inequities emerge: some racial groups were overrepresented in certain courses and underrepresented in others. Table 6 below shows the enrollment by racial category in each math course at Waterview High, as well as a racial breakdown of students not taking math.

Table 6

Senior Enrollment, by Racial Category, In Math Classes[3]

Math Course	Asian	Black/ African-American	Latinx	Pacific Islander	Mixed Race	White	Decline to State
No Math	18.50%	47.10%	31.50%	50.00%	22.00%	18.80%	0.00%
Algebra/ Geometry	1.50%	5.90%	0.00%	0.00%	0.00%	0.60%	0.00%
Algebra 2	3.10%	0.00%	9.60%	50.00%	6.00%	2.60%	0.00%
Pre -Calculus	10.00%	5.90%	12.30%	0.00%	6.00%	14.30%	0.00%
Statistics	16.20%	23.50%	24.70%	0.00%	12.00%	18.20%	0.00%
AP Calculus	32.30%	11.80%	9.50%	0.00%	14.00%	27.70%	0.00%
AP Statistics	18.50%	5.90%	12.30%	0.00%	40.00%	22.70%	100%
Total	100.00%	100.00%	100.00%	100%	100%	100%	100%

Among seniors not taking math, 50.00% of Pacific Islander Students, 47.10% of Black students and 31.50% of Latinx students are not taking math. In contrast just 18.50% of Asian students and 18.80% of White students are not taking math. These are the only two racial groups who have a significantly lower percentage of students not taking math than the schoolwide average of 22.6%.

There are important differences in course enrollment by student demographics, specifically race/ethnicity. Asian and White students are more likely to be in the calculus pathway (32.3% and 22.7%, respectively), while Black and Hispanic students are more likely to be in the statistics pathway (23.5% and 24.7%, respectively). The two-year calculus pathway consists of Pre-Calculus and AP Calculus. Students are not required to take Statistics before AP Statistics, so that pathway could be either one or two years. However Asian and White students are taking AP Calculus at higher rates than Black and Hispanic students are taking AP Statistics.

[3] The n for both Pacific Islander students and Decline to State is less than 10, so interpret those data with caution.

Eighth Grade Course-Taking

Since the math course students take senior year is in-part determined by what course they take in 8th grade, an analysis of 8th grade course taking is necessary to understand students' math course trajectories through high school. To do this, I used matched data on seniors' 8th grade math course with their 12th grade math course. The analysis only includes seniors who attended in-district schools in 8th grade. Additionally, I removed seven students in self-contained Special Education math classes which were not part of the Algebra→Geometry sequence. Thus, for the remainder of this chapter, when using administrative data to analyze 12th grade math course taking by 8th grade course enrollment, only the 323 students who were in Waterview's district for 8th grade and took general education math courses are included in Table 7.

Table 7

Seniors Taking Math Who Were Enrolled In-District in Eighth Grade

	n	%
2023-2024 seniors taking math who were enrolled in-district in eighth grade	261	79.09%
2023-2024 seniors not taking math who were enrolled in district in eighth grade	69	20.90
Total	330	100%

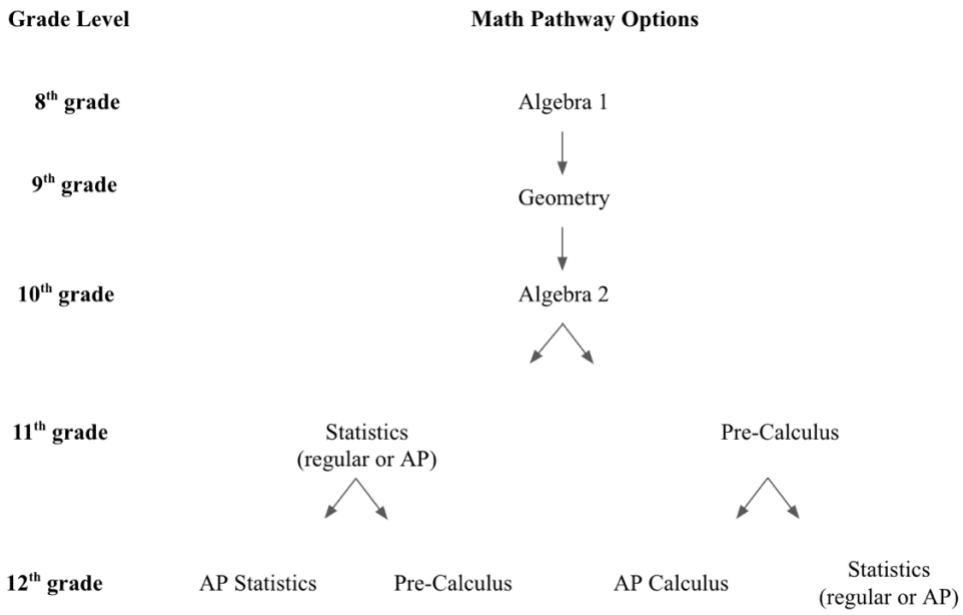
Note. This senior math course-taking data set individually matches seniors' 8th grade math course with their 12th grade math course and only includes seniors who attended in-district schools in 8th grade.

Eighth grade is the first year that students have options for what math course they take: 8th grade math, Algebra 1 or Geometry. There are no consistent criteria at each of the four district middle schools to determine which math track students enter in eighth grade, and an analysis of that criteria is outside the scope of this research. Students who take an advanced eighth grade course (Algebra 1 or Geometry) complete Algebra 2 at or before sophomore year, providing more time in their junior and senior year schedules to take a fourth or fifth year of math. Figure 7 below

uses eighth grade Algebra 1 as an example to display the various math pathway options a student has if they take an advanced math class beginning in 8th grade.

Figure 7

Secondary Math Pathway Options



Three math courses are available to students directly after Algebra 2: Pre-Calculus, Statistics, and AP Statistics. Taking advanced math in eighth grade allows students to take multiple advanced math courses.

When looking broadly at senior course-taking by eighth grade enrollment, important differences emerge. Table 8 maps the math course taken by eighth graders to the percentage taking math senior year.

Table 8

Senior Math Course-Taking by Eighth Grade Math Course

	8th grade math course							
	8th grade math		Algebra 1		Geometry		Total	
	n	%	n	%	n	%	n	%
12th graders taking math	138	53.28%	63	24.32%	58	22.39%	259	100%
12th graders not taking math	48	75.00%	7	10.94%	9	14.06%	64	100%
Total 12th graders	186	57.59%	70	21.76%	67	20.74%	323	100%

Of students not taking math senior year, 75% of them took Common Core eighth grade math. Students who took an advanced course in eighth grade were more likely to take math senior year than those who were not tracked into an advanced math class. To illustrate which courses eighth grade students ultimately took in the 12th grade, Table 9 shows senior enrollment at Waterview High by what course students took in eighth grade.

Table 9

Percent of 12th Grade Enrollment in Math Courses by Eighth Grade Math Course

	12th grade course							
8th grade course	No Math	Geometry	Algebra 2	Pre-Calculus	AP Calculus	Statistics	AP Statistics	Total
8th grade math	25.81%	0%	8.06%	16.67%	4.84%	24.19%	20.43%	100%
Algebra 1	10.00%	0%	0%	7.14%	37.14%	12.86%	32.86%	100%
Geometry	13.64%	0%	0%	4.55%	50.00%	4.55%	27.27%	100%

Unsurprisingly, the journey from eighth grade math to 12th grade math is very different depending on where a student started. Interestingly, about 25% of students who did not accelerate

in eighth grade still ended up taking AP math senior year. Nearly 25% of students who took Algebra 1 in ninth grade took AP Statistics as seniors after taking Algebra 2. AP Statistics is available to all students as a fourth year of math regardless of what course they took in eighth grade. The approximately five percent of students who took Algebra 1 in ninth grade and took Calculus senior year must have taken at least one summer online course to accelerate, since the track from Algebra 1 to Calculus requires five years of math.[4] A nearly equivalent number of students who took Algebra 1 in eighth grade take AP Calculus (32.86%) and AP Statistics (32.86%) as seniors. This is also reflected in Figure 7 above showing that about 50% of seniors taking math are enrolled in the Statistics/AP Statistics pathway, and about 50% are enrolled in the Pre-Calculus/Calculus pathway. Among the advanced courses, AP Statistics is the only course with a similar distribution of students from each eighth-grade math course. Prior research has emphasized the importance of a data science/Statistics pathway as an alternative way to ensure that all students, regardless of eighth grade math tracking, have access to an AP math course within four years of high school math (Anderson & Burdman, 2022; Daro & Asturias, 2019).

How Students' Final Year of Math Fulfills Graduation and College Eligibility Requirements

There are various reasons why students take math beyond the two-year minimum requirement for graduation. To find patterns in math enrollment, it is important to consider the math courses seniors took in light of what high school requirements and/or college entrance requirements they fulfilled. Wainstein et al.'s (2023) analysis created a framework to understand seniors' math course-taking decisions through the lens of what purpose that final course fulfilled.

[4] For example, for the upcoming summer of 2024, there are 121 WHS students signed up to take an online summer math course to use for advancement in the 2024 2025 school year. This is about 6% of the total student-body, not counting graduating seniors, but counting incoming 9th graders as they are also allowed to take a summer math course. These courses are not offered within the school district; students sign up and pay for them privately.

Below is an adaptation of that framework for students in this study, which is a useful model for analyzing students' math course-taking patterns and what graduation or post-secondary requirements are fulfilled by students' final year of high school math.

In this study's adaptation of Wainstein et al.'s (2023) model, students who were not taking math were grouped into categories by their final high school math course. Seniors not taking math in 12th grade are categorized by the final high school math course they took, no matter what year of school they took it in. For seniors who were taking math, the course used for this categorization was their math class in the 2023-2024 year. As seen in Table 10 below, Group 1 students' final math course of Geometry fulfilled the minimum two-year requirement for graduation.[5] Group 2 students' final math course was Algebra 2, which fulfilled their minimum A-G requirements of three years of math. Finally, Group 3 students are those who took at least one advanced course beyond Algebra 2. Of the graduating class of 2023-2024, 100% of students have met or will meet their minimum two years of math required for graduation.

[5] Of the 24 students in Group 1, seven are in Special Education and never took an A-G math course. Their final course was Strategic Algebra, a self-contained course which is part of a 2-year math sequence for students in Special Education whose skills are far below high school level. These seven students are represented in this chapter's administrative data but were not considered for analysis from the survey data since their needs are outside of the scope of this research.

Table 10

Senior Enrollment in Math Classes (N=430)

	12th Graders Overall		12th Graders Taking Math		12th Graders Not Taking Math	
	n	%	n	%	n	%
Group 1: Needed final math course to meet graduation requirements (2 years)	24	5.58%	4	1.20%	20	20.62%
Group 2: Needed final math course to meet A-G requirements (3 years)	76	17.67%	20	6.01%	56	57.73%
Group 3: Final math course was an advanced math course (4 years +)	330	76.74%	309	92.79%	21	21.65%
Total	430	100.00%	333	100.00%	97	100.00%

Nearly 93% of seniors taking math took an advanced math class, well above the state average of 60% (Reed et al., 2023b). Since such a high percentage of seniors taking math were in an advanced class, there was a lot of overlap in data for the remaining two research questions around why students chose to take math senior year and why they chose to take advanced math. Among this group, nearly 99% will meet their A-G requirements by the time they graduate. This is also far higher than the state average of 79% of seniors taking math taking Algebra 2 or higher.

When looking at the final math course taken among seniors not taking math, there is more variance between the three groups. Among those not taking a math class in senior year, just over 20% took an advanced math class prior to senior year. Of those students, all had taken Algebra 1 or Geometry in eighth grade. The majority of students not taking math senior year (57.73%) completed Algebra 2 and their minimum A-G requirements in a previous year, then stopped taking math. About 20% of students not taking math senior year stopped after Geometry, the two-year math course minimum for graduation. Looking at schoolwide data through this framework is helpful background information for the subsequent two chapters of this dissertation, which will analyze how students made their math course choices.

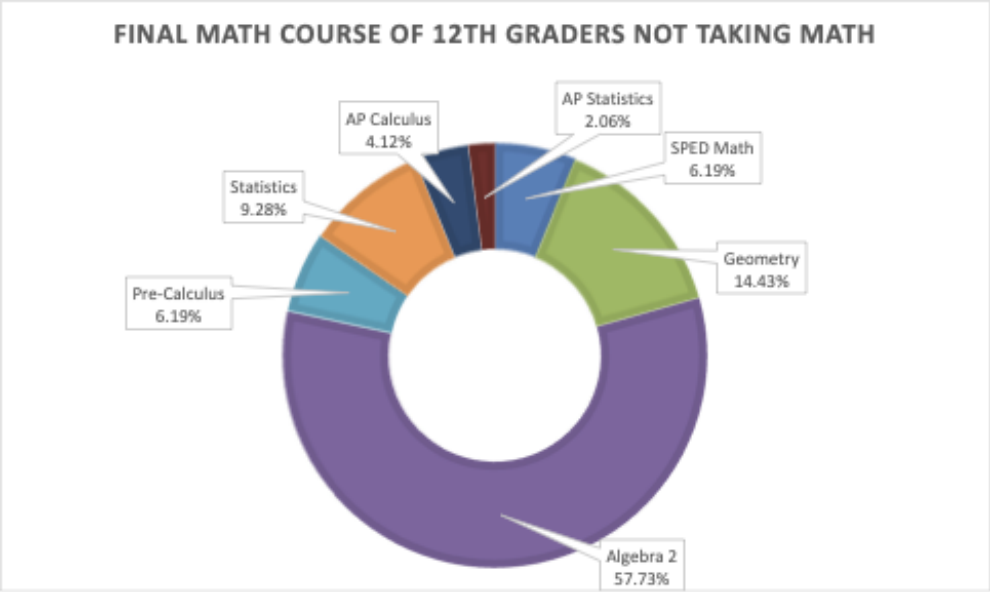
Of the students who were taking math senior year, the most common course taken was AP Statistics and the second most common course was Statistics. This aligned with schoolwide trends: the statistics pathway is equally as desirable and popular as the calculus pathway. But why was such a high proportion of students taking AP Statistics? The literature suggests that students who are interested in social science majors in college generally take a statistics pathway instead of a Pre-Calculus pathway (Gao, 2016). However, this data raises another possibility: For students who do not take Algebra 1 (or Geometry) in eighth grade and do not take a math course to accelerate over the summer, AP Statistics is the only AP math course available to them senior year. For students who took Algebra 1 as ninth graders, just over six percent of them are taking Calculus as seniors. Since it takes five years of math to reach Calculus, these students must have taken a summer online course to accelerate. Undoubtedly, it is difficult for students who are not placed in advanced math courses in eighth grade to access Calculus by 12th grade. Meanwhile, nearly 28% of seniors who did not take advanced math in eighth grade and took Algebra 1 in ninth were taking AP Statistics, as it can be taken as a fourth year of math.

Analysis of Students Not Taking Math

While studies illustrate that a significant proportion of students are not taking math through Algebra 2 to meet their A-Gs (Reed et al., 2023b; Wainstein, 2023), this was not the case at Waterview High. Of the 22.6% of Waterview High students not taking math senior year, 100% of them have met their graduation requirements. Figure 8 below shows the final math course taken by these students.

Figure 8

Final Math Course of 12th Graders Not Taking Math



Considering that only 61% of students completed their A-G requirements in math statewide (Reed et al., 2023), Waterview High's data is quite positive. Of the 22.6% of Waterview High seniors not taking math, nearly 80% of them met their A-Gs by the end of 11th grade.

Summary

The administrative data from Waterview High's seniors displays similarities and differences to statewide trends. Overall, a similar proportion of seniors are not taking math at Waterview High as in the state of California. Given this distribution of data, I tackle the question of why 22% of Waterview High students did not continue taking math senior year beyond the minimum A-G requirements. Using survey data, I will examine the responses of students who did not take math senior year but who took Algebra 2 junior year to gain insight into the decision-making of students who met their A-Gs but decided not to enroll in an advanced math course. Notably, among the students enrolled in math their senior year, a far higher proportion of students enrolled in the statistics pathway and took AP Statistics. Understanding why these trends exist

will be explored in the next two chapters using survey data that asked seniors about their course choices.

CHAPTER 6: QUANTITATIVE FINDINGS ON RESEARCH QUESTION #2

Introduction

The following two chapters will consider students' decision-making to answer my second research question and its sub-question: *How do seniors explain what prevented or facilitated their decision to enroll or not enroll in math their senior year?* and *How do seniors perceive their experiences in math classes and the importance of taking advanced math classes in high school?*

In this chapter I provide a quantitative analysis of all surveyed seniors. The analysis of students' survey responses is through the lens of Thompson's (2017) framework, looking at three categories of influences over students' course taking decisions: institutional, classroom and individual factors. Student quotes from open-ended follow up questions will be used throughout this chapter to more clearly illustrate themes emerging from the quantitative survey data. A thorough qualitative analysis will follow in the next chapter.

Data Analysis

When first writing the survey, I organized questions into institutional, classroom and individual factors based on the topics explored in my literature review. For students taking math senior year, the administrative data analyzed in the previous chapter illustrates that the vast majority of 12th graders taking math (93%) are taking an advanced course a year or two beyond the minimum 3-year requirement to meet A-G eligibility. Because 93% of Waterview High seniors who are taking math are taking an advanced math course beyond Algebra 2, we can think of seniors who are taking math as nearly synonymous with seniors who decided to take advanced math. Since nearly all seniors who are taking math are taking advanced math, this second research question on decision making around senior year math enrollment and its sub-question on advanced math are blended together in this chapter.

Because the overwhelming majority of 12th graders taking math are taking an advanced math course (93%), responses from students taking math will be grouped together as "math course takers" for the remainder of this dissertation. Among the 53 surveyed students not taking math, there is wide variation among what their final math course was prior to senior year. Of surveyed students not taking math senior year, 20.62% stopped after Geometry, 57.75% stopped after Algebra 2 and 21.65% took an advanced math course prior to senior year. The analysis of survey responses for students not taking math will be consistently disaggregated into three groups by their final math course. Group 1 are students who took two years of math and whose final course was Geometry. Group 2 are students who took 3 years of math and whose final course was Algebra 2. Finally, Group 3 are students who took four or more years of math and whose final course was an advanced math course beyond Algebra 2.[6] These three categories roughly correspond to students who took the minimum to graduate, those who took the minimum to meet their A-G eligibility, and those who took advanced math beyond that.

For the quantitative data analysis of survey questions, I organized the data into these same three categories. For each analyzed question, I disaggregated data into four categories: students taking math; students not taking math whose final math course was Geometry; students not taking math whose final math course was Algebra 2; and students not taking math whose final math course was advanced. My analysis compares data among each category of students not taking

[6] There is one notable exception. There are two groups of students who are not taking math senior year and who are in Wainstein et. al's (2022) categorization of students who met minimum 2-year graduation requirements. First, there are students who took Algebra 1 and Geometry to meet the graduation requirements. Second, among this group there are 5 seniors in Special Education who never took general education math courses and met their graduation requirements by taking 2-years of a self-contained Special Education Intensive Pre-Algebra and Algebra sequence. Four of these 5 students took the survey, however because these self-contained special education math classes are outside the scope of this research and there is such a small number of students in this group, their responses are not included in this data analysis of Group 1 students who took 2-years of math to meet graduation requirements.

math in addition to an overall comparison with all students who are taking math. Near the end of the survey, students were asked two open-ended questions, "What can Waterview High School administrators, teachers and counselors do so that more students are successful in math classes here (at any grade level)." and "What else should we know about math classes and students' decisions about whether or not to take math at Waterview High School that we haven't asked you about." Although a systematic analysis to these two questions are outside the scope of analysis for this dissertation, some quotes are used in this chapter to provide specific examples to further illuminate the quantitative results and add more direct student voice.

Results and Emergent Themes: Institutional Factors

In this study, institutional factors are defined as those within the control of the school site or the school district. There are four institutional factors that can be analyzed by this survey: first, the impact of tracking, specifically what eighth grade math course a student took and how it impacted their college readiness; second, the graduation and college-going requirements for Waterview High School and how prepared students were; third, the opportunities that students were offered to make up credit in classes required for college admission; and finally, the role school counselors played in influencing course-taking decisions. Each of these institutional factors are explored and compared through survey responses of seniors who were and were not taking math.

Course Tracking

The student survey (Appendix 1) explored one influence of tracking by asking what math course students took in eighth grade—the year math class tracking formally begins in the relevant district. Of the 57 surveyed students who were not taking math senior year, 54 of them were in-district in the eighth grade. Of those 54 students, 36 of them (67%) took eighth grade Common

Core Math, 13 of them (24%) took Algebra 1 in eighth grade, and five of them (9%) took Geometry in eighth grade. Students who took a high school math course in eighth grade (Geometry and/or Algebra 1) would hypothetically have had more time to complete their A-G requirements in high school, since that freed up a class block or two in high school; the survey data supports this premise. For surveyed students who took eighth grade Common Core math and who were not taking math senior year, 50% reported having met their A-G requirements. Comparatively, 69% of surveyed students taking Algebra 1 in eighth grade not taking math senior year reported having met their A-G requirements. Finally, 80% of surveyed students who took Geometry in eighth grade not taking math senior year reported having met those college-going requirements. In other words, there seems to be a positive correlation between students taking math above their grade level in eighth grade and students achieving A-G requirements.

Students meet A-G requirements through two criteria: by taking classes in all subject areas required by the UC and Cal State university system, and earning at least a C or higher in each of those courses. Students who took eighth grade Common Core math were more likely to receive at least one D or F in a high school class than those who took an advanced eighth grade math course of high school content as shown in Table 11.

Table 11

Questions 20-22: Surveyed Students Not Taking Math Senior Year Who Received At Least One D or F in a Class Required for College Admission

	Surveyed Students	Students who received a D or F in a required class for college eligibility		Students who made up their D or F to regain college eligibility		
8th grade math course	n	n	%	n	%	Most common course receiving the D or F
8th grade math	36	26	72.22%	13	50%	Algebra 1 and Geometry
Algebra 1	13	6	46.15%	3	50%	History
Geometry	5	3	40.00%	1	33.33%	AP Physics and Pre-Calculus
Total	54	35	64.81%	17	48.57%	

These data demonstrate that although students taking Algebra 1 or Geometry in eighth grade were more advanced when starting high school, they still received Ds or Fs in classes required for college at moderately high rates. Students at grade level in eighth grade math received a low grade in a class necessary for college eligibility at a very high rate (72%). Interestingly, students in all three eighth grade math tracks made up those credits at similar rates.[7] Despite this similarity, students at grade level in eighth grade math struggled in math at higher rates in high school than students who took more advanced math in middle school. While it makes intuitive sense that advanced middle school math students would do better in high school courses, the result is increased flexibility in their schedules by senior year, as they had fewer courses to make up credit in to maintain college eligibility.

[7] It is' important to note that an extremely small number of students (3) were surveyed who took Geometry in 8th grade.

High School Graduation and College-Going Policies

Waterview High School requires just two years of math for graduation, and three years of math are the required minimum to meet California college eligibility requirements. These requirements affect whether students take math senior year, as math becomes optional senior year if students have met those two benchmarks.

When asked if they had time to complete their A-G requirements, nearly 90% of surveyed students taking math responded yes. There was wide variation in responses within each of the categories of students not taking math, as shown in Table 12.

Table 12

Question 4: Students with Adequate Time to Complete A-G Requirements

		Did you have time to complete A-Gs?			
Senior Math Course-taking	n	Yes	No	Not	Not sure
Taking math senior year	286	89.51%	2.80%	4.90%	2.80%
Not taking math senior year	53	56.60%	5.66%	20.75%	16.98%
		Final Course			
Geometry	7	0.00%	0.00%	42.86%	57.14%
Algebra 2	31	54.84%	6.45%	25.81%	12.90%
Advanced Math	15	86.67%	6.67%	0.00%	6.67%

Of students not taking math, those whose final math course was advanced completed their A-G requirements at nearly the same rate as students who took math senior year. Just over half of the students whose final course was Algebra 2 had time to complete their A-Gs, implying that they had a D or F in math or another subject. Over half (57.14%) of the seven students whose final course was Geometry said they were not sure if they had met these requirements, demonstrating

that many students who met only the minimum math requirements for graduation were not aware of these college entry requirements.

When asked what administrators, teachers, and counselors could do to increase the percentage of seniors taking math, numerous students taking math suggested raising the graduation requirements to at least three if not four years of math. Perhaps not surprisingly, of the seniors not taking math, none suggested raising the graduation requirements.

Master schedule issues did not significantly affect whether students took math senior year. This said, not having enough time in their four years to take all the classes they wanted had a higher impact on students taking more advanced math courses. Some students had to decide between a math class and a valued other class which were both taught the same period. Table 13 shows students' responses to two questions on the impact of master schedule decisions on students' math course taking.

Table 13

Questions 12-13: Impact of Master Schedule on Math Course Taking

		There has been a time at AHS when I didn't get into a math course I wanted to take		During my time at WHS, there was a math class I Wanted to take, but I couldn't fit it in because of other courses I need to fit into my schedule	
Senior Math Course-taking	n	Yes	No	Strongly Agree/ Somewhat Agree	Strongly Disagree/ Somewhat Disagree
Taking math senior year	286	11.54%	88.46%	15.38%	84.62%
Not taking math senior year	53	9.43%	90.57%	20.75%	79.25%
		Final Course			
Geometry	7	0.00%	100.00%	0.00%	100.00%
Algebra 2	31	0.00%	100.00%	3.23%	9.68%
Advanced Math	15	13.33%	86.67%	26.67%	73.33%

Students taking and not taking math senior year responded similarly (around 10% for each group) about whether there had been a time in high school where they did not get into a math course they wanted to take. Among students not taking math, the only ones who had this experience of a class being full were students who took an advanced math course in junior year. This implies that for the 13% of students in this category who responded yes, they could not get into the course of their choice for senior year, though it is also possible they took an advanced course junior year which was not their first choice. This, for example, could happen when a student wants to take AB Calculus but, as it is full, they take AP Statistics or regular Statistics instead.

There were larger differences among math takers and non-math takers where fitting a desired math class into their schedule was concerned. About 20% of students not taking math responded that there was a math class they wanted to take but could not fit it in because of other courses needed to fit into their schedule. Likewise, compared to the other two categories of students not taking math, students not taking math senior year whose final course was an advanced course responded most frequency that there was a desired math course that they could not fit into their schedule senior year.

Opportunities to Make Up Credit in Classes Required for College Admission

Students were asked if they had ever received a D or an F in a class required for graduation or college admission and, if so, whether they had had the opportunity to make up that credit. Among students not taking math, there was substantial variation in student responses depending on their final math course. Because I work at this school, I know that the most common way for students to make up a low grade in a course is to repeat the course for credit using an online platform. At Waterview High, students make up credits via a program called Edmentum. Table 14 shows data of students who have received a D or F in any course and if they made it up via online credit.

Table 14

Survey Question 18: Have you ever gotten a D or F as a semester grade in any high school class?

		Have you ever gotten a D or F as a semester grade in any high school class? If so, did you make up the credit?		
Senior Math Course-taking	n	Yes	No	I made up the credit
Taking math senior year	286	22.73%	77.27%	38.46%
Not taking math senior	53	62.26%	37.74%	42.42%
		Final Course		
Geometry	7	85.71%	14.29%	50.00%
Algebra 2	31	70.97%	29.03%	45.45%
Advanced Math	15	33.33%	66.67%	40.00%

Of students taking math senior year, about one in four (22.73%) had received a D or an F and of those, just over a third (38.46%) had made up the credit, placing them back on an A-G eligibility track. In contrast, nearly two-thirds of students not taking math senior year (62.26%) had received a D or an F, and two in five (42.42%) made up the credit. Since these students were not taking math senior year, it is possible that some used an extra open class spot to make up credit from a previous low grade.

Disaggregating the data of non-math takers by their final course reveals even more variation in responses. For students whose final course was Geometry, 85.71% received a D or an F in a prior course. Of those students, half of them made up the credit. The D/F rate for seniors whose final math course was Algebra 2 was slightly lower (70.97%) but still extremely high. For this group of students, nearly half (45.45%) were able to make up the credit via an online course or by repeating the course. Students not taking math whose final course was an advanced math course received a prior D or F at a much lower rate (33.33%) than non-math takers in the other two categories, implying that they were doing better in school overall.

Just as there was wide variation among non-math takers for D/F rates, there was also wide variation in the class where students received a D or an F. Table 19 shows what subjects were most common for students who received a D or an F. In Table 15, English and History courses are grouped together as humanities and each subject is divided up by A-G required courses and more advanced courses (which are either courses beyond the minimum A-G requirement in that subject area or AP courses).

Table 15

Question 21: Most Common Course with a D or F (Survey Question 19)

		In what course(s) have you received a D or an F?								
		Foreign Language		Humanities		Math		PE	Science	
Senior Math Course-taking	n	Required for 4-year college eligibility	Adv./ AP	Required for 4-year college eligibility	Advanced/ AP	Required for 4-year college eligibility	Adv./ AP	A-G	Required for 4-year college eligibility	Adv./ AP
Taking math senior year	286	11.58%	0.00%	18.95%	4.21%	37.89%	10.53%	4.21 %	7.37%	5.26%
Not taking math senior year	53	5.17%	0.00%	20.69%	0.00%	48.28%	5.17%	3.45 %	12.07%	5.17%
					Final Course					
Geometry	7	0.00%	0.00%	42.86%	0.00%	57.14%	0.00%	0.00 %	0.00%	0.00%
Algebra 2	31	6.06%	0.00%	21.21%	0.00%	48.48%	0.00%	3.03 %	12.12%	0.00%
Advanced Math	15	16.67%	16.67 %	0.00%	0.00%	0.00%	16.67%	0.00 %	16.67%	33.33%

For all seniors, the subject area with the most Ds and Fs was overwhelmingly math. Humanities classes (English and History) were the second most common to give grades below a C.

When looking at seniors not taking math, the data varies among students who had to make up a D or F grade. Seniors not taking math whose final course was Geometry or Algebra 2 received a D or F in a math class (57.14% and 48.48%) at far higher rates than students taking

math senior year (37.89%). In contrast, of seniors not taking math whose final course was advanced math, none had a D or an F in Algebra 1, Geometry, or Algebra 2, and just 16.67% had a D or F in their previous advanced or AP math class. Among students not taking math whose final math class was advanced, their most common prior D or F was in AP Physics.

Of seniors not taking math whose final class was Algebra 2 or below, all prior Ds and Fs were in A-G required classes, meaning that they had to be made up to maintain A-G eligibility. Making up these low grades to maintain college eligibility resulted in less time in senior year student schedules for an additional math class. In contrast, the D/F rate for students not taking math whose final class was an advanced one is far lower, and nearly all of those low grades were in advanced classes that did not impact A-G eligibility.

The Role of School Counselors in Students' Decisions to Take Math Senior Year

When proactively talking with students about the long-term value of taking advanced math classes in high school, school counselors have the potential to make a positive impact on students' course-taking decisions (Lee & Ekstrom, 1987; Sciarra, 2010). Multiple students responded on the survey that they were transfer students from another high school and wished their counselor had better explained the math sequences to them when they enrolled to ensure they were placed in the right class based on math classes at their previous school (which was sometimes out of the country). Table 16 shows survey data by subject area on students who responded 'A Lot' or 'Somewhat' on whether their counselor had given them advice on course selection.

Table 16

Question 23: "Sometimes school counselors talk with students about their course selection, especially when thinking about post-high school plans. For each subject below, how much has your counselor given you advice to help you decide course selection?"

		For each subject below, how much has your counselor given you advice to help you decide course selection?			
Senior Math Course-taking	n	English	History	Math	Science
Taking math senior year	286	14.34%	13.29%	26.22%	22.38%
Not taking math senior year	53	18.87%	22.64%	35.85%	33.96%
Final Course					
Geometry	7	42.86%	57.14%	42.86%	42.86%
Algebra 2	31	22.58%	25.81%	35.48%	32.26%
Advanced Math	15	0.00%	0.00%	33.33%	33.33%

Interestingly, in every subject, students not taking math senior year responded that they received more advice from their counselor on course selection compared with those taking math. Both students taking math and those not taking math hypothesized that one reason students do not take math senior year is because of how overloaded their schedule was junior year to prepare for college applications.

Across high school subjects, math is the course where students report receiving the most advice on course selection from their counselor. But when disaggregating the data among each category of non-math takers, different trends emerge. Students whose final course was Geometry reported receiving the most advice on course selection for every subject area. Coupled with the earlier data on higher D/F rates, these students may have needed more advice, as their lower grades in certain classes meant they could not simply enroll in the subsequent course as planned without a strategy for remediation. Waterview High reported high D/F rates in sophomore year Modern World History, which may be why students in this group reported receiving the most

advice about history course selection. Students whose final math course was advanced math were most likely to receive course-taking advice in math and science. These students may overlap with students reporting in the open-ended responses that they decided not to take math senior year in order to focus on an AP science class.

In short, a complex set of institutional factors are interwoven into students' decisions about whether or not to take math senior year. Both quantitative and qualitative survey data illustrate the ways that the course students took in eighth grade, high school graduation policies, opportunities to make up credit for semester grades of Ds and Fs, and school counselors' influence on math course-taking selections.

Classroom Factors

Teachers have the most direct influence over classroom factors. The importance of a student's sense of belonging in math class, teachers who consistently deliver high quality math instruction, and teachers who provide multiple opportunities to demonstrate mastery of course content are all high-leverage factors that impact whether or not a student chooses to take math senior year once they are no longer required to do so.

Students' Sense of Belonging in Math Class

Teachers' attention to the social-emotional needs of students and their ability to tap into students' creativity and personal interests both impact a student's sense of belonging in class (Boaler & Greeno, 2000; Smith et al., 2021). Boaler and Greeno (2000) compared discussion-based classrooms against didactic teaching with traditional lectures and found that students who stop taking math often do so because they prefer courses with more opportunities for expression, interpretation and agency. Many students taking math senior year pointed out how a strong sense

of community in their earlier math classes influenced their decision to take math senior year. Three questions on the student survey provided data on students' sense of belonging in class.

Seniors taking math and students not taking math both overwhelmingly reported (70.98% and 79.25%, respectively) that they would take more math classes in high school if more real-world connections were built into the course. Students reported they would have taken more math if it related more to the real world at similarly high rates across all three groups of students not taking math in senior year. Interestingly, students whose final course was advanced math were most likely to report that they would have taken more math if it had more real-world connections. In response to a question asking what changes could be made to encourage more students to take advanced math senior year, students in every category of non-math takers frequently mentioned examples of how they wished math class was more connected to real-world topics.

A second survey question to gather data on students' sense of belonging in math class asked if they felt successful in last year's math class. Table 17 has the percentage of students who marked strongly agree or somewhat agree to the statement that they felt successful in last year's math class.

Table 17

Survey Question 29: In Math Class Last Year, I Felt Successful.

	In math class last year, I felt successful	
Senior Math Course-taking	n	%
Taking math senior year	286	61.89%
Not taking math senior year	53	35.85%
Final Course		
Geometry	7	0.00%
Algebra 2	31	29.03%
Advanced	15	66.67%

Even for students who went on to take math senior year, just 61.89% felt successful in math the previous year. For students not taking math, just 35.85% felt successful in their previous year of math. These low numbers are even more concerning when looking at students whose final course was Geometry (0% felt successful in their last math course) and Algebra 2 (29.03% felt successful in their last math course).

High-Quality Math Instruction

High-quality math instruction is delivered through the hundreds of teaching decisions teachers make daily as they determine how to best support student learning. Ball (2018) names these decisions as ones made in discretionary spaces. Table 18 shows the percentage of students who responded that they strongly agreed or agreed that their math teacher last year was able to help them understand what was being taught.

Table 18

Question 29: In math class last year, my teacher was able to help me understand what was being taught.

	In math class last year, my teacher was able to help me understand what was being taught.	
	n	%
Taking math	286	73.78%
Not taking math	53	56.60%
Final Course		
Geometry	7	14.29%
Algebra 2	31	51.61%
Advanced	15	86.67%

Students not taking math in senior year but whose final class was advanced math had the highest rate of students agreeing that their last math teacher was able to help them understand what was being taught. This implies that for these students, other factors were more influential in their decision to not take math senior year. In contrast, just 14.29% of non-math takers whose final course was Geometry and just over 50% of non-math takers whose final course was Algebra 2 agreed that their teacher helped them understand the material.

The final survey question related to high-quality instruction asked if the teacher's teaching style was helpful towards the student's learning. Though there was no survey question asking about specific teaching methods, Boaler & Greeno's (2000) study of math course-taking patterns comparing didactic and discussion-based classrooms found that students who struggled with math continued to take more math classes when teachers used more discussion-based pedagogy. Table 19 shows the percentage of students in each group who responded that they strongly agreed or agreed that in their previous math class, the style of teaching was helpful in their learning.

Table 19

Question 29: In math class last year, my teacher's teaching style was helping in my learning

	In math class last year, my teacher's teaching style was helping in my learning	
	n	%
Taking math senior year	286	62.59%
Not taking math senior year	53	41.51%
Final Course		
Geometry	7	14.29%
Algebra 2	31	32.26%
Advanced	15	73.33%

Similar to responses to previous questions, students not taking math whose final math class was advanced had teachers whose pedagogy worked for them, as illustrated by the 73% who agreed with this question statement. Though survey did not specifically ask about teaching methods, this is yet another indicator that many students whose final course was Algebra 2 or Geometry stopped taking math because they faced challenges in learning the material from their teacher.

Multiple Opportunities to Demonstrate Mastery

Being given multiple opportunities to demonstrate mastery is a factor in students' math course-taking decision-making that counts as both an institutional factor and a classroom factor. Schools providing ways for students to make up Ds and Fs via retaking a course, summer school, or online programs is an institutional factor, since that is a system overseen by school administrators and counselors. Teachers' influence on providing multiple opportunities to demonstrate mastery is in how they provide tutoring and classroom retake policies for tests and quizzes (Gutiérrez, 2000).

Seniors were asked on the survey if they had ever struggled in a math class. Those who had struggled were asked two open-ended follow-up questions on what was challenging about the

class when they struggled, what supports were offered, and how helpful were they. Table 20 disaggregates the data for students who responded 'yes' to the question asking if they had ever struggled in a math class.

Table 20

Question 18: Have you ever struggled in a math class at WHS?

	Have you ever struggled in a math class at WHS?	
	n	%
Taking math senior year	286	69.93%
Not taking math senior year	53	84.91%
Final Course		
Geometry	7	85.71%
Algebra 2	31	87.10%
Advanced	15	80.00%

A high percentage of all seniors have struggled in a high school math class. Interestingly, this is the only survey question where students not taking math had a similar percentage of affirmative responses in every category. Struggling is not necessarily a bad thing; often, struggling is how we learn. How teachers provide multiple opportunities to demonstrate mastery not only affects if students want to continue taking math classes, but also their confidence in class. Table 21 has the challenges which emerged for seniors not taking math organized by theme and disaggregated by final math course.

Table 21

Question 18: When you have struggled in math class, what was challenging about it for you?

When you have struggled in math class, what was challenging about it for you?	Seniors not taking math: final math class		
	Geometry	Algebra 2	Advanced Math
	%	%	%
ELL Math Vocabulary	13.33%	3.23%	0.00%
Counselor placed me in wrong class	0.00%	0.00%	8.33%
Math has always been challenging for me–moves too fast and too much to remember	53.33%	45.16%	25.00%
Perception that my teacher didn't care about my learning or didn't make me feel smart	0.00%	16.13%	33.33%
Too much HW/Too overwhelming	13.33%	22.58%	16.67%
Self-conscious about not understanding	0.00%	0.00%	8.33%
I have never been interested in math	13.33%	3.23%	0.00%
Struggled online (COVID) and never caught up	6.67%	3.23%	0.00%
I need a different way of learning	0.00%	3.23%	0.00%
Mental Health is disrupting my learning	0.00%	3.23%	8.33%
Total	100.00%	100.00%	100.00%

When seniors not taking math were asked if they had ever struggled in a math class, around half of students whose final course was Geometry or Algebra 2 mentioned that their biggest challenge was that math class had already been hard, moved too fast, or was simply too much to remember. In comparison, just 25% of seniors who took advanced math in 11th grade felt this was their biggest challenge. Specific rationales about why math class was so hard varied. Students who stopped taking math after Geometry often seemed overwhelmed with everything in class. STuent

Student perceptions that their teacher did not care about their learning or did not make them feel smart was the biggest reason for struggle among students not taking math whose final course was advanced math. The students who named this reason as most influential often compared themselves to other students in the class who they perceived were smarter than them.

Nearly 70% of seniors taking math reported that they had struggled before in previous math classes. When asked what helped them overcome their struggles, the most common answer was ways they had received tutoring. While these included some predictable responses—from private tutors to family members, to after-school or advisory tutoring from their math teacher—one common response mentioned by seniors taking math was that study groups coordinated and led by either myself or the school intervention teacher helped them succeed. This feedback about the value of study groups from seniors taking math who had struggled junior year is supported in numerous studies on how to support and promote students of color in STEM college majors (Palmer, Maramba & Dancy, 2011; Triesman, 1992).

All surveyed students had their math trajectories influenced by the quality of their math teachers and classroom pedagogy. The three categories explored in the student survey were students' sense of belonging, high quality math instruction, and multiple opportunities to demonstrate mastery, and students reflected the importance of all three of these factors in their answers.

Individual Factors

The individual factors contributing to student course decision-making explored in this dissertation are adapted from multiple studies about students' self-perception as math students, how they feel about the importance of taking as much math as possible, and their expectations around post-secondary plans (Cribbs et al., 2015; Ozturk & Singh, 2006; Simpkins et al., 2006). The specific survey questions addressing individual factors center on the questions from Eccles (1983) Expectancy-Value Model: "Can I do it?" and "Do I want to do it?" (Eccles & Wigfield, 2002, as cited in Thompson, 2017).

Can I Do It? Do I Want to Do It?

The survey asked four questions on students' self-perception as math students. Students responded on a Likert scale with one being strongly disagree and 5 being strongly agree. The data from those who marked a four or a five with a self-perception as confident or successful is summarized in Table 22 below.

Table 22

Questions 34-37: Seniors' perception of themselves as math students

		Percentage of students who agree with the following statements			
		I like math	I'm good at math	I feel confident as a math student	When I try my best I can be successful in math class
	n	%	%	%	%
Taking math senior year	286	39.86%	47.20%	53.15%	76.92%
Not taking math senior year	53	13.21%	30.19%	20.75%	58.49%
Final course					
Geometry	7	0.00%	14.29%	0.00%	28.57%
Algebra 2	31	9.68%	19.35%	12.90%	51.61%
Advanced Math	15	26.67%	73.33%	53.33%	86.67%

Overall, an extremely low percentage of polled seniors at Waterview High like math. Even among students taking math senior year, less than 40% responded that they like it. Although a low percentage of students in all groups agreed that they liked math, in general a higher percentage agreed that they were good at math, felt confident as a math student, and believed they could be successful when trying their best. Interestingly, students not taking math whose final course was advanced agreed that they were good at math at a far higher rate (73.33%) than students who took math senior year (47.20%). It is interesting that such a high percent of these students felt they were good at math, and yet stopped taking it senior year.

The second set of questions related to individual factors affecting whether students took math senior year. Those questions centered on how students evaluated the importance of math class relative to their lives after high school. Table 23 shows students who strongly agreed or agreed with the statement that math class in high school was important for achieving their post-high school plans.

Table 23

Question 37: Math class in high school is important for achieving my post-high school plans.

	Math class in high school is important to achieve my post-high school plans	
	n	%
Taking math	286	63.99%
Not taking math	53	33.96%
Final Course		
Geometry	7	42.86%
Algebra 2	31	22.58%
Advanced	15	53.33%

Looking at this data alongside data on students' post-secondary plans helps make sense of these responses. Table 24 shows students' post-secondary plans.

Table 24

Survey question 2: What is the highest level of education you hope to achieve?

		High School Degree	Community College (Associate Degree)	4-year College (Bachelor's Degree)	Graduate Degree	Total
	n	%	%	%	%	%
Taking math	286	2.10%	2.10%	53.85%	41.96%	100.00%
Not taking math	53	8.77%	17.54%	47.37%	26.32%	100.00%
			Final Course			
Geometry	7	14.29%	42.86%	28.57%	14.29%	100.00%
Algebra 2	31	12.90%	19.35%	45.16%	22.58%	100.00%
Advanced	15	0.00%	0.00%	53.33%	46.67%	100.00%

Interestingly, while over 90% of seniors taking math planned to earn a bachelor's or graduate degree, less than two-thirds of them agreed that math class in high school was important for achieving their post-secondary plans.

Seniors not taking math whose final course was Geometry did not meet their A-G requirements as they only took two years of math, yet nearly 43% agreed that math was important for achieving their post-secondary plans. Over 40% planned to earn a bachelor's or graduate degree. Since these students were only eligible for community college immediately after high school, it was possible that they knew that they needed to improve their math skills during their time in community college.

Less than one-fourth of students whose final course was Algebra 2 agreed that math was important for their post-secondary plans. These students were eligible to attend a four-year college straight out of high school since they took Algebra 2 prior to senior year. Of these students, just under 70% saw themselves earning a bachelor's or graduate degree.

Finally, of students whose final math course was advanced, barely 50% saw math as important for their post-secondary plans, yet 100% of them planned to earn either a bachelor's or graduate degree. This group of students reported the highest percentage in expecting to earn a graduate degree (46.67%).

Influence of Family and Peers

Numerous studies have shown that families have a significant impact over how much math students take in high school and their decision-making around whether to attend college (Kevelson et al., 2023; Ozturk & Singh, 2006; Sciarra, 2010). Table 25 has survey data on how often during high school seniors had discussed going to college with someone in their family.

Table 25

Question 3: How often have you discussed going to college with someone in your family?

		How often have you discussed going to college with someone in your family?	
		All the time, often, or sometimes	All the time
	n	%	%
Taking math	286	91.26%	32.17%
Not taking math	53	90.57%	22.64%
Final Course			
Geometry	7	100.00%	0.00%
Algebra 2	31	87.10%	9.68%
Advanced	15	93.33%	60.00%

When grouping responses together for "all the time," "often," and "sometimes," the data looks similarly high for seniors taking math and not taking math—and even among the three groups of

students not taking math. In general, most students were talking about college to some degree with their families.

When only looking at students who chose "all the time," however, there were significant differences among groups. The only group of students who had over 50% response rate in this category were the seniors not taking math whose final course was advanced. This group of students were advanced in math in eighth grade, took four years of high school math, and made a conscious decision to stop taking math for senior year despite 60% of them talking to their families "all the time" about going to college. Their responses to the open-ended question of what the most important factors in their course-taking decisions were explained how students from this group most commonly chose to stop taking math in order to have time in their schedules to focus on advanced classes in other subjects.

Conclusion

Institutional, classroom, and individual factors (Thompson, 2017) interconnect to explain what prevented or facilitated seniors' decision to enroll or not enroll in math their senior year. Whether or not students took math senior year was not necessarily a binary yes/no decision but was made through "tension between individual choice and structural constraints." (Kurlaender & Hibel, 2018) This trend is illuminated even more clearly when disaggregating the survey data by the final math course taken by seniors not taking math senior year.

Institutional factors explored in this analysis illustrate how certain school policies influence math course taking. First, the grade in school when students take Algebra 1 is correlated with them finishing all of their 4-year California university eligibility requirements. Next, the data illuminated whether students were able to get into the math courses they wanted and if they could fit those courses in with other needed courses. This included how getting Ds and Fs impacted

students having time to complete all courses required for 4-year California university eligibility requirements and whether students had opportunities to make up those credits to regain eligibility. Finally, survey data illuminated the influence of counselor's course taking advice.

The analysis of classroom factors shed light on math teachers' influence on students' future math course taking decisions. Survey responses illustrated students' sense of belonging in math class including how successful they have felt in previous courses, how effective math teachers had been in help students understand what was being taught, and how a teacher's pedagogical approach impacted students learning. Additionally, the data provides insight on what specific aspects of math class had been challenging in seniors' previous courses.

Finally, survey data explored what individual factors were most impactful to students when making math course taking decisions for senior year. Students' opinions and the opinions of their friends and family on the value of taking advanced math classes, their post-high school plans, and how they view themselves as math students were the factors analyzed.

CHAPTER 7: QUALITATIVE FINDINGS ON RESEARCH QUESTION #2

Introduction

This final findings chapter provides a qualitative analysis for two open-ended survey questions asked only to students not taking math: *Tell us more about why you're not taking math this year?* And *What was most important to you in making that decision?* While the previous chapter used quotes from other open-ended questions to provide more nuance to the quantitative data, this chapter provides a formal analysis of responses to just these two questions to more deeply understand my second research question and subquestion: How do seniors explain what prevented or facilitated their decision to enroll or not enroll in math their senior year? How do seniors perceive their experiences in math classes and the importance of taking advanced math classes in high school?

Qualitative Data Analysis Process

Thematically organizing data from these two open ended questions was developed and refined in several phases. I began with in vivo coding (Saldaña, 2013), creating codes from scratch using phrases from students' responses. Next, I re-read each of the quotes, considering if it fell into a second category. From there, I used process Coding (Saldaña, 2013) to develop longer descriptions which became my code definitions. Through this iterative process, I combined some codes when I discovered they were both connected to the same theme. The code definitions are included below in my codebook. My next pass on my index of codes was to consider Thompson's (2017) institutional, classroom and individual factors that impact student achievement and I organized my codebook using these categories. Finally, throughout the analysis, I disaggregated students' responses into the same three categories used when analyzing administrative data: students whose final math class was Geometry, Algebra 2 or an advanced

class. The purpose of this was to better understand the intersectionality between the last math class a student took and their decision-making process on senior year math course taking. All 57 surveyed students who are not taking math responded to this set of open-ended questions.

Throughout this process I was keeping in mind the theoretical framework of Kurlaender and Hibel's (2018) Constrained Choice Theory that often students' decision-making on course selection illuminates a "tension between individual choice and structural constraints." As I reviewed the open-ended responses to these two questions around the factors students considered in their decision-making on taking math in their senior year, I was constantly reminded from students' open-ended responses that institutional, classroom and individual factors are not distinct categories, rather an intersecting set of influences.

My first emergent theme was institutional factors. There are four primary codes in this category: math didn't fit into my schedule, I failed a semester of a class in a prior year and needed to make up credit, there was no math class of interest, and I wanted to take it but my counselor didn't put it on my schedule. I lumped each of these codes into institutional factors as each are in the nexus of influence of school staff outside the classroom.

The second emergent theme was classroom factors. These are all factors which a math teacher has the most significant influence over. Those codes include: dislike of prior math teacher, a dislike of math because it was stressful or harmful to a student's self-confidence, not understanding a prior math class, and math class generally being too much work or too hard.

Finally, individual factors were grouped together into emergent themes. Those codes are: not wanting math for post high school plans, not needing any more math credit, wanting an easier senior year or a free period, not realizing math is important for the future, concerns that math

class would negatively impact GPA, a perception of not being good at math, and preferring to take other classes.

To maintain anonymity, all references to a specific teacher's name have been removed and all quotes are included exactly as typed by students on the survey, maintaining any grammar or spelling errors. Errors are not marked with "[sic]," as they are often simply typing errors and repeated use of "[sic]" would interrupt the reading flow of the students' quotes. After this analysis of qualitative responses, the chapter continues by sharing findings from the survey's closed-ended questions.

Results and Emergent Themes

When asked, "What can AHS administrators, teachers and counselors do so that more students are successful in math classes here (at any grade level)?" (Appendix 1), one senior responded, "We're still kids. Things would be easier on us if teachers and such thought about our perspectives. What would help us learn?" Findings in this chapter will do just that: consider students' perspectives. Table 26 below shows the themes that emerged from the in vivo and process coding described above. The table is organized by emergent themes, which are then divided into three categories based on a student's final math course prior to senior year. Since many student responses raised factors from more than one code, the total number of occurrences is larger than the number of students in each group.

Table 26

Codebook of Responses From Seniors Not Taking Math to the Questions: Tell us more about why you're not taking math this year? What was most important to you in making that decision?

			Responses disaggregated by final math course					
	Open ended responses: Tell us more about why you're not taking math this year? What was most important to you in making that decision?		Geometry		Algebra 2		Advanced Math	
	Primary Code Name	Code Description	n	%	n	%	n	%
Institutional Factors	Didn't fit in schedule	Students who wanted to take math but the math class they wanted to take conflicted with a class period of another class they needed or wanted to take.	0	0.00%	1	1.75%	0	0.00%
	Failed a prior class and needed to make up credit	Students whose primary reason for not taking math senior year was not having time in their schedule because they were making up credits from a previously failed course.	1	12.50%	0	0.00%	0	0.00%
	No Math class of interest	Students who didn't have a math class that interested them. This also includes students who wanted to take non AP Calculus which wasn't offered this year (but has been in the past)	0	0.00%	1	1.75%	0	0.00%
	Thought I would take it but it wasn't on my schedule	Students who expected to take math and were surprised to not see it on their schedule (assumed that meant their couselor didn't sign them up for it)	0	0.00%	1	1.75%	0	0.00%
Classroom Factors	Dislike of math teachers	Dislike of a former math teacher or bad experiences with math teachers in high school was the primary factor OR they started a class senior year and dropped it because of the teacher	0	0.00%	3	5.26%	2	6.90%
	Dislike of math/Stressful/ Hurts my self confidence	Students didn't take math senior year because of how much they didn't like (or hated) or felt stressed out by a previous math class.	2	25.00%	10	17.54%	0	0.00%
	I didn't understand a prior math class.	Primary reason is that a previous class was so hard that they didn't think they could do well in the next one.	0	0.00%	0	0.00%	1	3.45%
	Too much work/It's hard	Primary reason was how hard math class is, while specifically mentioning how much work math class is as their reason for not taking it.	0	0.00%	8	14.04%	1	3.45%
Individual	Don't want it for post high school	Students who had the math they needed for their post-secondary plans AND specifically said they didn't need more math for their intended work or college plans/major. This includes students who said they planned to attend community college	1	12.50%	0	0.00%	3	10.34%
	Don't need math credit	These students' primary reason for not taking math senior year was that they already had the credits they needed for their post-secondary plans. Some had 2 years for graduation, others had 3 meeting A-G, and others took advanced math classes in the summmer or Algebra in middle school and already had 4 years of high school math before senior year.	3	37.50%	15	26.32%	11	37.93%
	Easy Senior Year/Free Period	Specifically mentioning wanting an easier senior year or room for a free period in their schedule	0	0.00%	5	8.77%	2	6.90%
	I didn't realize it was important for my future	Students who mentioned in the survey that they didn't realize taking 4 years of math was important or who are now wishing in hindsight that they had taken math senior year.	1	12.50%	0	0.00%	0	0.00%
	Impact on Grade	Taking math senior year would lower their GPA or they knew they fear	0	0.00%	6	10.53%	2	6.90%
	Not Good at Math	Primary reason is that they don't feel they are good at math and it's too hard.	0	0.00%	6	10.53%	0	0.00%
	Preferred other class	Students whose priority for senior year was other challenging courses (AP Science courses were most mentioned and AP Literature)	0	0.00%	1	1.75%	7	24.14%
	Total		8	100.00%	57	100.00%	29	100.00%

Not Needing More Math Credit

Students gave a variety of reasons for not taking math. For all three groups of students, the most common reason for not taking math was that they already had the math credits required to meet their post-graduation goals. However, students from each group gave different specific explanations for their thinking.

Final course Geometry Of the students whose final course was Geometry, not needing additional math credit was often the only reason given, with no secondary reasons. Among these students, there was an emphasis on not planning to attend college at all or planning to attend community college. For example, one student in this category explained, "I might go to community college because i don't plan on going for a 4-year state college. My counselor said i Didn't need it anymore but it will be useful for college credits but i only want to graduate for now."

Final course Algebra 2 Students whose final course was Algebra 2 mentioned having already met their minimum four-year college eligibility to explain why they did not need additional math credit, but they elaborated far more on how that impacted their decision-making. Responses in this group were characterized by an emphasis on not liking math, feeling they were not good at it, or their feeling that doing well simply took too much work. One student explained, "i met my uc requirements, and since i plan to go straight into school after high school, why not take a easy year with no math, since i struggled in math." Similarly, another responded, "I didn't need any advanced math courses for my career or major after high school, and it's a large stressor for me and I would've fallen behind much quicker if I took one this year."

Final course Advanced Math Of students whose primary reason for not taking math was that they already had sufficient math credit, there was a lot of overlap between students whose

final course was Algebra 2 and those whose final course was an advanced math course. There are two common themes among these groups: both specifically mentioned having already completed A-G eligibility in math and being prepared for college admissions, and both had critiques of prior math courses. The only notable difference among responses of students in these two groups is that those whose final math course was an advanced one specifically mentioned having already taken four years of high school math. One student explained, "I decided to not take math this year simply because I found it to be useless as I have completed all my math credits up to calculus." Another student offered more pointed commentary on prior math classes: "I took algebra 1 in eighth grade therefore under A-G eligibility I already have 4 years of math. Additionally, all of the math teachers I've had have been genuinely miserable people, high strung, bitter, and prone to snapping at the students, making the classes unenjoyable so that discouraged me significantly."

Differences in emergent themes depending on a student's final math class

Taking a deeper dive into themes found in each category of students not taking math, there were distinct differences in the responses of students whose final math course was Algebra 2 or below compared to students whose final course was an advanced class. Students whose final course was Algebra 2 or below frequently mentioned not taking math senior year either because of how much they disliked it or how stressful prior courses had been for them. Some comments, such as this one from a student whose final course was Geometry, are very straightforward: "I have fulfilled my math requirements and I knew if I had taken a math class, it would have stressed me out." Many others from students whose final course was Algebra 2 explain in detail how stressful past math classes have been. For example: "Math has been a constant source of stress to me throughout all of my education and I feel that my focus on being able to maintain a decent

grade in math in turn directed my focus away from my other classes and lowered my grades in them. I probably would have failed." Another student wrote: "I hate doing math not going to lie to you. I just couldn't stand working so hard every day and night, come to class, SMART period [advisory], lunch and after school to just to fail my classes." Finally, this response from a student whose final course was Algebra 2 wove together a complex narrative of how a lack of confidence in math built over several years and ultimately resulted in not choosing to continue taking math classes:

> I am not taking math this year because I have not been very confident with math and I didnt want taking math to make my school year stressful. I have a lack of confidence in math due to the fact that in 9th grade, my math teacher quit 2 weeks into our semester and the school never did anything to rectify the situation. This led to a very challenging sophmore year when it came to the subject of math. I was having a really hard time and it took me so long to catch up. Thankfully, I had the worlds greatest math teacher sophomore year!!! she took the time to help me as much as she could to understand what I missed the year prior. She enrolled me in 9th grade level khan academy so that I could study the old concepts that I hadnt learned yet, and she took the time to help me during smart periods [advisory] and this helped me feel extra prepared for tests. I worked really hard during this year and felt that I was doing much better. But then the following year (junior year) I was now in algebra 2. This is when the lack of algebra 1 really caught up to me. I struggled a lot in this class and lost all of the confidence I had built up in sophomore year. By the end of the year I felt like there was no hope for me. I chose not to do math this year because I had lost all confidence in math again and I

> didnt want it to impact my senior year since I am involving myself in so many other academic activities outside of school that it wasnt worth the stress.

Although the stress of math class was frequently mentioned by students not taking math whose final course was Algebra 2 or below, it was not mentioned a single time by students whose final class was advanced math.

In contrast to the stressful nature of math class as explained by students not taking math whose final course was Algebra 2 or below, students whose final course was advanced math most commonly responded that they stopped taking math once they no longer needed the credits for graduation or college because of a desire to prioritize other classes for senior year. Although a few of these students talked about wanting an easier senior year and therefore chose an elective class in the arts or a free period instead of math, the majority of responses specifically mentioned not taking math in order to take an advanced course in a different subject area or a course to prepare for their intended college major. Students in this category most often mentioned that they took an AP science class instead of math. One student explained how their intended major affected their math course-taking decisions—specifically their decision to not take math senior year to focus on an advanced science class:

> I'm going into the nursing profession, and statistics is more needed than calculus so I decided to take it right after honors pre-calc in my sophomore year. I wanted to get it done junior year so I could focus more on my advanced science course senior year. Including the AP Statistics course, that's 5 high school math courses I had already completed by the end of my junior year of high school (I took two high school math courses in middle school).

The responses of seniors not taking math whose final course was an advanced course demonstrated that they were aware that they had already taken four years of high school math and made an informed decision to take a different subject in line with their intended post-secondary goals instead.

Infrequently Mentioned Reasons for Not Taking Math

It is also important to examine which reasons for not taking math were less commonly mentioned. Few students specifically mentioned the quality of math teachers as their reason for not taking math senior year. For students whose final course was Geometry, no one mentioned a dislike of prior math teachers. Just over five percent of students whose final course was Algebra 2 and those whose final course was advanced math mentioned bad experiences with prior math teachers as their reason for not taking math senior year.

Among all students not taking math senior year, several reasons were only given once: math not fitting into a student's schedule; failing a prior class (of any subject) and needing to make up the credit to graduate; not realizing math was important for their future; not understanding a prior math class; not having a math class of interest to take; and wanting to take math, but a counselor not scheduling the student for it.

Conclusion

This final findings chapter was a qualitative analysis of open-ended responses by seniors not taking math on two open-ended questions: Tell us more about why you're not taking math this year? What was most important to you in making that decision? Although the most common response to this set of questions was students explaining that they did not need more math credit, a more thorough coding and analysis revealed that students' decision-making took many more factors into account, which differed based on the level of their final math course.

CHAPTER 8: CONCLUSION

Introduction

> *I planned to take math for all four years of high school–not taking a math class this year was not part of the question for me.*

This research gives insight into how much of high school students' enrollment in four years of math is a conscious decision and how much is the result of other structural realities in a school and/or bias of adults in the school who have influence over students' course selections. Structurally, math becomes optional at some point in most California high schools, as only two years are required by the state for graduation. Informally, there is an association between doing well in advanced high school math courses and a perception of smartness (Boaler & Greeno, 2000; Dunleavy, 2018). Formally, there is extensive research positively correlating taking four years of math in high school with multiple long-term outcomes, including four-year college enrollment, persistence, and higher income (Conley, 2006; Gao, 2021; Hayward, 2021; James, 2013; Rose and Betts, 2004; Trusty et al., 2008). However, despite the positive outcomes associated with taking math, it remains a subject in which not everyone believes they can be successful. The yearnings of this senior would resonate with many students: "Lots of kids just don't like math because they feel inadequate. I feel that math should be advertised as being for everyone. It's not just for 'smart' people."

The purpose of this study was to investigate math course-taking patterns to discover why these patterns exist. Research for this study began with administrative data from a suburban, Northern California high school, which was used to answer the following questions: *What are patterns and inequalities in math course-taking among seniors at a high performing, diverse suburban school? What are the patterns in 4th year math enrollment by demographics and prior academic achievement?*

The patterns which emerged guided data analysis on a second set of research questions, uncovered through a mixed-methods survey given to all seniors at this same high school. The survey was designed around three overarching spheres of influence on math course-taking decisions: institutional, classroom, and individual factors (Thompson, 2017). The survey was also used to answer two additional research questions: (1) How did seniors explain what prevented or facilitated their decision to enroll or not enroll in math their senior year?, and (2) How did seniors perceive their experiences in math classes and the importance of taking advanced math classes in high school?

Together, site-level administrative data and student voice data from the survey shed light on the highest leverage factors in explaining why these math course-taking patterns exist. This mixed method analysis suggests how best to increase the percentage of students taking and succeeding in four years of math while in high school.

Synthesis of Findings

Waterview High School boasts similarities and differences to statewide math course-taking patterns. The analysis of administrative data illuminated several unique patterns in fourth year math enrollment. Although the overall percentage of seniors not taking math was similar to the statewide average, a much higher percentage of students did take a fourth year of math (93%) than the average statewide in California (66%)—particularly in Statistics and AP Statistics, where over half of seniors taking math were enrolled (Read, et. al., 2023b). Creating the conditions for students to take and succeed in four years of math is something to be celebrated at Waterview High School.

However, working to eliminate inequalities by race are an area of growth. For Waterview High School staff. Black and Latinx students were more likely not to be taking math than students

of other racial categories. Additionally, Black and Hispanic students were less likely to have taken advanced math in eighth grade (Algebra 1 or Geometry); as a result, they had less access to advanced math classes in high school than students who started taking high school level math while in middle school. These findings corroborate the findings that tracking increases inequality by race and socio-economic status in access to college level course work (Wells, 2018; Terrin and Triventi, 2023). When correlating eighth grade math courses with whether or not a senior took math, students who took an advanced math course in eighth grade were more likely to be taking math senior year than students who did not take Algebra 1 until ninth grade. The analysis of administrative data illustrates that while a far higher percentage of Waterview High School's students are taking advanced math compared to statewide data, disproportionality in achievement by race and eighth grade tracking status persisted.

Why Are Students Not Taking Math Senior Year?

The survey data from seniors adds more depth of understanding into students' decision-making around whether to take math senior year. Looking through the interconnectedness of Thompson's (2017) three lenses of institutional, classroom, and individual factors, certain key themes emerge. For example, taking an advanced math course in eighth grade was correlated with taking math senior year as well as completing one's A-G requirements. Students who took Algebra 1 or Geometry in eighth grade had less overall Ds and Fs in all subject areas than students who took eighth grade math. This data should be treated cautiously since there is selection bias in the correlation between taking advanced math in eighth grade and receiving less Ds and Fs in high school classes

Students in all groups mentioned their decision over whether to take math was influenced by whether they needed it for their intended college major. Similar to studies positively

correlating increase math course taking in high school with post-secondary outcomes (Hayward, 2021; Kettler and Hurst, 2017; Park-Taylor et al., 2022) students taking math senior year were more aware of A-G requirements and reported having met them, compared with students not taking math. Both students taking and not taking math overwhelmingly would take more math if it had more real-world connections. It would be interesting to explore within traditional courses and newer alternative courses such as data science what students' overall level of enjoyment of those courses was, and whether enjoyment improved when teachers worked to consistently connect math to real-world applications.

Although full classes or scheduling conflicts did not come up as a major factor influencing students' class-taking decision-making, a few issues nevertheless arose. Though many students reported they had had time to complete their A-Gs, and a similar percentage of students taking and not taking math reported a time when they could not get into a course they wanted, about 10% of students had this happen. However, a higher percentage said that there was a math class they wanted to take but could not because it was full. This happened most often with honors and advanced level classes offering fewer sections; these were more likely to conflict with another specialized course, such as a specific elective or a specialized science class. For example, Biotech was only offered during one or two periods, which obviously limited scheduling availabilities.

Having other priorities in their course selection for senior year was another common theme among all students. For example, some students reported not taking math senior year to focus on other advanced classes, such as an AP science course which they worried would be too hard to take in addition to an advanced math class. Others reported not taking math to have a free period to make up a D or F in a prior year's course, particularly to maintain A-G eligibility.

Finally, some students simply reported their desire to balance out their senior year by not taking too many advanced classes to focus on applying to college and spending time with friends.

A small percentage of students reported not taking math because they did not get into the math course of their choice. The only students who reported this as their reason for not taking math were those whose final math course junior year was an advanced course. These responses were most likely due to students getting on a waitlist for AB Calculus and not wanting to take AP Statistics or regular Statistics instead. Other explanations may also have applied; perhaps some students did not get in to the advanced math course of their choosing and decided to focus on different courses for senior year, such as computer science or AP computer science. The data from Waterview High School seniors illustrates that the decision on whether or not to take math senior year wasn't simply a binary yes/no decision, aligning with Kurlaender and Hibel's (2018) constrained choice theory.

In various ways, students in all categories raised how stressful, challenging, and disconnected from the real world high school math classes could be. Since this survey only asked students their opinions on math class, there was no data to compare to how they feel about other high school courses.

Influences on Students' Math Course-Taking Decisions

Interestingly, among all categories of surveyed students, there were similar percentages of students who reported liking math class and/or feeling confident in math class. How a student felt about math class was therefore not the driving force determining whether they continued taking math through senior year. Among seniors schoolwide, there were low percentages of students who reported a sense of belonging in math class or liking the previous year's math class. Yet, relative to state averages, a huge percentage of students at this high school persisted in math and

took advanced courses past minimum requirements. Even among students taking math senior year, just 60% reported liking it the year before, which meant that 40% of students who reported not liking math junior year continued to take it senior year.

Students discussed various people who had influenced their course decision-making: friends, teachers, counselors, and family members. Those whose intended post-secondary plans involved a STEM major or job in a STEM field reported that taking math all four years of high school was important to achieve that goal. About 44% of all University of California students major in a STEM field (University of California, 2023). Since taking more math in high school was positively correlated with good postsecondary outcomes for all majors, the importance of influencing seniors to take math regardless of their plans after high school seems clear. Students not taking math whose final course was Geometry found the advice of their counselors to be most influential. This could suggest that, when students were struggling in Algebra and Geometry, their counselors pointed out that two years of math was all that was needed for graduation.

Students had many reflections on how counselors influenced their course-taking decisions. Counselors were named as being part of conversations about balancing senior-year workloads against applying to college, students' desire to be done (aka "senioritis"), and many students' feelings that they were already accomplished and ready for college. Many student responses implied that students got more advice about their course selections for junior year than senior year. Counselors also gave more advice on course-taking in all subjects to students not taking math. This may be because students not taking math had a significantly higher percentage of Ds and Fs in all classes, necessitating conversations about course selection and making up credits. Sciarra (2010) and Kusko (2020) suggest that counselors have a responsibility to proactively work with students to overcome the barriers of taking four years of high school math. When

considering course selection for senior year, students with prior Ds and Fs mentioned their counselor had advised keeping a free period for self-paced online credit recovery classes, which likely impacted math enrollment.

Study Limitations

There are some limitations to the analysis of math course-taking via administrative data. First, I did not look at if students were taking a computer science course. Computer science counts as a fourth year of math once you have already taken Algebra, Geometry and Algebra 2. Students who marked on the survey that they were not taking math senior year may actually have been taking computer science, and who would be considered to have four years of math in the eyes of the University of California system. Second, the graduating class of 2023-2024 at this high school was the last class able to take Geometry in eighth grade. Since the school board eliminated this course offering in eighth grade for future cohorts, senior course-taking patterns will change in subsequent graduating classes. The consequences of this change are already bearing out: only 12 students have signed up for BC Calculus in the 2024-2025 school year at Waterview High, an enrollment figure so low that the course is likely to be cancelled. Finally, I did no analysis of grades, which created two limitations: First, for college-going eligibility, I made the assumption that students had earned a C or higher in a lower course if they were enrolled in the next year's math class. Second, without a grade analysis, there was no way to disaggregate data by race or grade level to see how students were doing in each course, nor to compare grades in the statistics pathway against grades in the calculus pathway.

This study investigates math course-taking patterns in a single district at one high school. Although the data and conclusions can shed light on these phenomena in other cities with similar suburban demographics, it remains a singular portrait. In fact, this district has two

comprehensive high schools; as school enrollment is based on the zone where families live and this city, like many, has socioeconomic segregation, the demographics, strengths, and challenges of the math department across town are significantly different than they are at Waterview High. Although this mixed-method survey data provides rich student responses, the overall number of students in each category of students not taking math was small relative to the number of responses of students taking math. A more in-depth analysis could have involved interviews of students in each category, which would have allowed students to explain their math course-taking journeys in more detail. Finally, while administrative data uncovered disproportionality by race in who was taking math and what courses they are taking, this study does not dive into why this is happening.

Future Research

Educational research is often done by researchers who never have worked or are no longer working at a school site. In this study, I was able to rely on my professional role as Assistant Principal to collaborate closely with our school's math department and district administrators to ground the work in questions we, as a school-site, wanted to answer. This said, I could never have carved out time for analysis had I not also been using the research for my dissertation. The data collected from this study and subsequent analysis has already been used by school and district leaders to determine next steps for this school and district to increase the numbers of students taking four years of math and decrease disproportionality by race in meeting four-year college eligibility requirements. A priority for future research is to design a similarly themed survey that is simpler and shorter, which could readily be used by school administrators and math teachers to understand the highest leverage factors at their sites in course decision-making. This study did not

specifically look through an equity lens to understand why the variations in math course taking patterns occur. As a researcher who also is a school leader, this is a priority of mine.

Counselors have the potential to be very influential over students' course taking decisions and their advice could be biased in how they either encourage or discourage students from taking higher level math classes (Kusko, 2020; Lee & Ekstrom, 1987; Sciarra, 2010)). However, this survey did not explore what advice students were given by their counselors. How counselors' advice varies depending on their personal biases about a student or their former or current course selections is a topic worth exploring.

Another unexplored area that could be the subject of a smaller-scale student survey is around private tutoring. Although this survey did not specifically ask about tutoring, it was mentioned a few times as an example of a support in conversations about student struggling. Informally, students talked a lot about how they navigated a poor-quality teacher by hiring a private tutor. This is clearly not a resource accessible to everyone and exacerbates equity issues if hiring private tutors is having a significant impact on students' success in math class Furthermore, having a tutor would mask the true impact of a teacher. Any research on the impact of a high-quality teacher would also need to take into account who was using a private tutor and how that correlated to longer-term outcomes.

Finally, one theme on which there is no current research is the long-term outcomes of students who in a Pre-Calculus/AP Calculus pathway versus those who took Statistics/AP Statistics. As one student explained: "I think the decision to take math or not most heavily relies on a students' value of college education, and how they want to set themselves up." What differences emerge in college enrollment, persistence, college major, future jobs, and earnings for students in each pathway? Such research would be especially beneficial for college counselors

and academic counselors who regularly advise students. This theme connects with the overwhelming student requests for teachers to infuse more real-world applications of math. From my work experience, pseudo-contexts are common, such as finding the equation of the parabola formed by an image of water leaving a drinking fountain. However genuine contexts, like calculating slope to build an actual wheelchair ramp with certain ADA specifications or an actual Waterview High statistics project where students analyzed if you are more likely to offer help to a student who trips and falls if it happens in the beginning or end of a passing period, are far rarer. With the growing focus on increasing percentages of students taking four years of math by offering multiple areas of math as pathways (Reed et al., 2023a; Reed et al., 2023c), this is a future area of research worth exploring.

Implications for Policy and Practice

Centering the voices and experiences of seniors around why they did or did not take advanced math in 12th grade has the potential to influence policy and practice in unique ways. Policy and practice changes can be implemented at three levels: K-12 districts and higher education leaders; high schools; and math teachers. This study may guide K-12 leaders in knowing where to focus their efforts to address outcomes like increased math enrollment, student engagement in math, and pedagogical changes.

K-12 District-Level and Higher Education Implications

For students not taking advanced math because they did not feel able to be successful or because they did not see its value, a diversification of math pathways offered in high schools could lead to more students finding value or success in math. The Launch Year Initiative through the Dana Center at the University of Texas, Austin is already working on this issue through the expansion of high school math pathways in ways aligned with the expanding and

evolving needs in the workforce (Kung & Fitzpatrick, 2023). By senior year, nearly all students are focused on their intended plans for after graduation. When taking a fourth year of math is a choice and not a requirement, students will be more likely to enroll when they see a direct connection between what they are learning in math class and their future.

Further research is necessary on increasing the math graduation requirements to three years to match the required three years for admission to a four-year public university in California. For raising graduation requirements in math to be successful, students must be prepared for the rigor of advanced math classes, and schools must have enough math teachers to raise the number of sections offered for each advanced course.

Another way leaders who oversee both K-12 and higher education can address low advanced math enrollment figures may be to develop a regular practice administering common assessments and looking at math data together. In K-12, there are generally more assessment measures in literacy than math. Giving district-wide math screening assessments to identify students in need of early intervention and developing common course assessments between sites could allow district leaders to foster a culture of data-informed decision-making. For higher education leaders, there are implications for students who are not taking math beyond Algebra 2, but plan to major in subjects requiring more advanced math. Access to more data can help prepare students and educators alike in addressing these challenges.

Site-Level Implications

Since parent expectations can influence how much students value taking advanced math, schools could host family math nights to ensure families understand the value of doing well in and continuing to take math, even when it is no longer required for graduations. At the elementary and middle school levels, schools can host family math night with the hopes of

sharing data with families to raise awareness in how they can influence their child's course choices as they get older. Family math nights could also ensure that all families have many opportunities over many years to learn about the significance of A-G requirements, and how taking advanced math can positively influence college acceptance rates. High schools can lean on their college and career counselors to hold events for ninth grade families to involve them in the course selection process and continue to help them understand the value of taking math in all four years of high school.

High school academic counselors also offer a lot of potential to support students in understanding the value of advanced math. One way to support counselors in this guiding role is with data and professional development on how to know who is not planning or eligible to enroll four in years of math and to set up meetings with those students. Counselors' influence can also extend to the master schedule; they could also work with school leaders to ensure there are sufficient spots in advanced math classes for all students, and that these classes are offered in multiple periods so as not to conflict with other required courses seniors need for graduation. Counselors can also create ways for students from historically underrepresented racial groups to have priority in advanced math class enrollment. Finally, a collaboration between counselors, site leaders, and math department chairs can ensure that funding is set aside for summer school and online classes—or that students are permitted to enroll in two math classes at the same time—to ensure multiple pathways for credit recovery for students who have earned a D or F in a required math class for college admission.

Implications for Math Teachers

Professional development for math teachers can increase the percentage of students taking four years of high school math by focusing on how to develop a strong classroom community

built on trusting peer relationships and creating genuine connections with the content of each math course to real-world concerns (Ball, 201; Krall, 2018; Seda and Brown , 2021). Math teachers have often had little training in how to lead discussion-rich classrooms; this is another area of potential professional development. Finding discussion-based math classrooms in high schools is far rarer than in elementary or middle school, particularly in more advanced classes where teachers tend to be more lecture-focused (Boaler & Greeno, 2000). A shift toward more collective engagement could be one way to retain student enrolment in advanced math.

Creating department-wide ways for students to have multiple opportunities to demonstrate mastery is another critical way that math teachers can support math students (Curley and Downey 2023; Feldman 2018; Gutierrez, 2000). Regular tutoring and intervention for students in any math course at risk of falling behind is something that can be systematically done throughout the department using data to monitor students. Collaborating with intervention teachers and others outside the classroom can also create a safety net for students falling behind. Creating math intervention during advisory periods or an extra period before or after school so that students can maintain their elective and get the support they need in these foundational math skills is another possibility. Offering summer school programs that provide a full year of credit for Algebra 1—a gatekeeper course—can allow students who earn a D or F in ninth grade to begin sophomore year in Geometry while also maintaining college eligibility if they earn a C or higher in summer school. Additionally, schools with significant populations of EL students might consider how to provide language support in math class to provide both a deeper understanding of math and stronger development of academic language in English (Sciarra, 2010).

The key practitioners behind my work are district leaders (Director of Equity, Director of Schools, District Secondary Math Coach), site leaders (Assistant Principals and Principals),

school counselors, math department chairs, and math teachers. This research can inform their day-to-day work as they work together within the K-12 system. Too often, school staff at all levels come together to brainstorm solutions to issues without including student voice and data. I hope my research can be a model for how site leaders can act as researchers through regular consideration of both administrative data and student voice data to influence their decision-making in addressing systemic issues.

Conclusion

It is my sincere hope that this research can fuel future studies to explore the key influences in students' math course-taking decisions in more depth. What I most hope is that my study may offer a model for doing research including student voices in a way that can be scaled down to something site administrators can do with ease and regularity. This study of seniors' math course-taking patterns and decisions is happening alongside a major policy debate among the University of California system on whether Algebra 2 should be a required course for four-year college eligibility in California, or if alternative pathways such as statistics and data science can also be used for A-G eligibility. The title of a recent article in the *Los Angeles Times* illuminates how emotional this policy discussion has become: "UC stirs furious debate over what high school math skills are needed to succeed in college" (Watanabe, 2024). This study echoes the themes emerging from these policy debates and explores ways to make secondary math more accessible, engaging and relevant so that a far higher percentage of seniors enroll and succeed in advanced math courses.

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Appendix 1

The survey questions used for this dissertation are taken from a longer survey developed in conjunction with the Waterview High Math Department. The longer survey was administered to all 11th and 12th graders in October 2023. All questions on the 12th grade survey were modified from prior published surveys gathering administrative data and on math course taking. Survey questions on institutional factors were modified from Navarette's (2020) survey of community college students. Good et al.'s (2012) study on belonging in math class was adapted for the portion of the survey on classroom factors. Individual factors included in the survey were adapted from multiple studies on value placed by students on excelling in math (Cribbs et al., 2015; Ozturk & Singh, 2006; Simpkins et al., 2006).

The 12th grade survey used for this dissertation is found here with n= approximately 450 students:

https://drive.google.com/file/d/1bVxqWbgPuslV2uoandfmc_bNIysmSdx4/view?usp=drive_link

The survey is also found below. The actual online survey is in sections, using survey logic, depending on responses to certain questions.

The purpose of this survey is to understand your experiences in math classes and will be used to improve both math teachers' and school counselors' ability to support students in math course-taking. The survey is anonymous and the ONLY reason it's asking you to log in with your email is so you can only complete it once. As it says under your email, your email is NOT SHARED and your answers are completely anonymous. Doing the survey is voluntary. If you have questions during or after taking the survey, you may ask Ms. Krasnow.

* Indicates required question

1. What grade are you in? *

Mark only one oval.

- ◯ 9th
- ◯ 10th
- ◯ 11th
- ◯ 12th

2. What is the highest level of education you hope to achieve? *

Mark only one oval.

- ◯ High School Degree *Skip to question 6*
- ◯ Community College (Associates) Degree *Skip to question 5*
- ◯ 4-Year College (Bachelor's) Degree *Skip to question 5*
- ◯ Graduate Degree post college *Skip to question 5*

3. How often during high school have you discussed going to college with someone in your family? *

Mark only one oval.

- ◯ Never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ All the time

4. I had time in my schedule this year to complete all my grade-level requirements for 4-year college eligibility (A-G eligibility) *

Mark only one oval.

- ◯ Agree
- ◯ Disagree
- ◯ I am not working towards being 4-year college eligible as I have other post-graduation plans.
- ◯ I don't know

5. What do you plan to study in college? Choose the one category you're most likely to study. *

Mark only one oval.

- ◯ Humanities & Arts (e.g., English, history, arts)
- ◯ Math or Engineering
- ◯ Health Services
- ◯ Natural Sciences (e.g., biology, chemistry, physics,)
- ◯ Social Sciences (e.g., education, psychology, sociology, economics)
- ◯ Business
- ◯ Applied Sciences (e.g. automotive repair, HVAC, construction)
- ◯ Undecided

6. Are you currently taking math at WHS? *

Mark only one oval.

- ◯ Yes *Skip to question 7*
- ◯ No *Skip to question 8*

7. How important were each of the following in your decision to take math this year? *

Mark only one oval per row.

	Not important	Somewhat important	Neutral	Important	Very important
Meeting my graduation requirements.	◯	◯	◯	◯	◯
Meeting my A-G requirements.	◯	◯	◯	◯	◯
The impact a class will have on my GPA.	◯	◯	◯	◯	◯
What classes my friends are taking.	◯	◯	◯	◯	◯
The opinion of my school counselor.	◯	◯	◯	◯	◯
The opinion of my family.	◯	◯	◯	◯	◯
The opinion of my friends.	◯	◯	◯	◯	◯
The opinion of my math teacher.	◯	◯	◯	◯	◯

Skip to question 10

8. How important were each of the following in your decision to not take math this year? *

Mark only one oval per row.

	Not important	Somewhat important	Neutral	Important	Very important
Meeting my graduation requirements.					
Meeting my A-G requirements.					
The impact a class will have on my GPA.					
What classes my friends are taking.					
The opinion of my school counselor.					
The opinion of my family.					
The opinion of my friends.					
The opinion of my math teacher.					

9. Tell us more about why you're not taking math at WHS this year? What was most important to you in making that decision. *

_____

_____

_____

_____

_____

Skip to question 10

Math Class Selection

10. What math class did you take in 8th grade? *

Mark only one oval.

- ◯ 8th grade Math
- ◯ Algebra 1
- ◯ Other: _____

11. For each year of high school, which math class did you take? If you ever took 2 classes in the same year, mark that here.

Check all that apply.

	9th grade	10th grade	11th grade	12th grade
Intensive Pre-Algebra	☐	☐	☐	☐
Strategic Algebra	☐	☐	☐	☐
Algebra 1/ Math 1	☐	☐	☐	☐
Geometry/Math 2	☐	☐	☐	☐
Algebra 2/ Math 3	☐	☐	☐	☐
Advanced Algebra 2	☐	☐	☐	☐
Pre-Calculus	☐	☐	☐	☐
Honors Pre-Calculus	☐	☐	☐	☐
Calculus (non AP)	☐	☐	☐	☐
AB Calculus AP	☐	☐	☐	☐
BC Calculus AP	☐	☐	☐	☐
Statistics	☐	☐	☐	☐
AP Statistics	☐	☐	☐	☐
I did not take math in that year.	☐	☐	☐	☐

I'm not yet in this grade in school.				

12. There has been a time at AHS when I didn't get into a math course I wanted to take. *

Mark only one oval.

- Yes
- No

Scheduling Questions

13. During my time at Waterview High, there was a math class I wanted to take, but I couldn't fit it in because of other courses I needed to fit into my schedule. *

Mark only one oval.

- ◯ Strongly Disagree
- ◯ Somewhat Disagree
- ◯ Somewhat Agree
- ◯ Strongly Agree

14. Beginning the summer before 9th grade, have you ever taken a math class for credit outside of WHS? *

Mark only one oval.

- ◯ Yes *Skip to question 15*
- ◯ No *Skip to question 17*

15. What math class(es) have you taken for credit outside of WHS?

16. Why did you decide to take a math class outside of WHS? *

17. Have you ever struggled in a math class at WHS? *

Mark only one oval.

- ◯ Yes *Skip to question 18*
- ◯ No *Skip to question 20*

18. When you have struggled in math class, what was challenging about it for you? *

19. What supports were offered and how helpful were they? *

Grades in School

20. Have you ever gotten a D or F as a semester grade in any high school class? *

Mark only one oval.

- Yes *Skip to question 21*
- No *Skip to question 23*

Making up Ds and Fs in high school

21. What class(es) did you receive a D or F in for a semester grade? *

22. For any classes with a D or F as a semester grade, were you able to make up the credit without having to retake it at WHS (summer school or an online course)? *

Mark only one oval.

- Yes
- No
- I have made up some, but not all of the credit.

Who has influenced your WHS course taking decisions?

23. Sometimes school counselors talk with students about their course selection, especially when thinking about post-high school plans. For each subject below, how much has your counselor given you advice to help you decide course section? *

Check all that apply.

	Never	A little bit	Somewhat	A lot
Electives	☐	☐	☐	☐
English	☐	☐	☐	☐
Foreign Language	☐	☐	☐	☐
History	☐	☐	☐	☐
Math	☐	☐	☐	☐
PE or PE Credit through a sports team	☐	☐	☐	☐
Science	☐	☐	☐	☐

24. How often during your time in high school has your counselor talked to you about the importance of taking math classes in high school? *

Mark only one oval.

- ◯ Never *Skip to question 26*
- ◯ Once or twice *Skip to question 25*
- ◯ Three or more times *Skip to question 25*

25. What did your counselor recommend about taking math? Did this have an influence on your decision about math course taking? *

What influences your math course taking decisions?

26. Who has recommended that you take an an advanced math course (something past Algebra 2) in high school? Choose all that apply. *

Check all that apply.

- [ ] No one
- [ ] Parent/Guardian/Relative
- [ ] Math Teacher
- [ ] A teacher other than math
- [ ] Counselor
- [ ] High school staff member (e.g. coach, secretary, principal, etc)
- [ ] Mentor or family friend (in school or out of school)
- [ ] Other: _____

27. What were the most important factors in your decision of whether or not to take math this year and which class to take? *

28. I would take more math classes at WHS if they had more real-world connections as part of the course? *

Mark only one oval.

- Strongly Disagree
- Somewhat Disagree
- Somewhat Agree
- Strongly Agree

Math Class

29. Think back to your math class LAST YEAR. If you didn't take math last year, think about the last math class you have taken at WHS. How would you describe the following? *

Mark only one oval per row.

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
My teacher was able to help me understand what was being taught					
I enjoyed the class.					
I felt successful					
My teacher's teaching style was helpful in my learning.					
The environment/classroom community was helpful in my learning.					

30. Think about the math class you took last year. Did you feel successful in it? Explain why or why not. *

How does it feel to be in math class at WHS?

31. What do you need from a math teacher to be successful? *

32. What can WHS administrators, teachers and counselors do so that more students are successful in math classes here (at any grade level)? *

33. I feel confident as a math student. *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

34. When I try my best, I know I can be successful in math class. *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

35. I'm good at math *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

36. I like math. *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

37. Math class in high school is important for achieving my post-high school plans. *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly agree

38. Math teachers at Waterview High would like for more students to take an advanced math class senior year. What are the most important things the school can do for this to happen? *

39. What else should we know about math classes and students' decisions about whether or not to take math at WHS that we haven't asked you about? *

40. Which of the following best describes your background? Select all that apply, *

Check all that apply.

- [ ] American Indian/Alaskan Native
- [ ] Asian/Asian American
- [ ] African American/Black
- [ ] Filipino
- [ ] Hispanic/Latinx
- [ ] Multi-Racial
- [ ] Native Hawaiian/Pacific Islander
- [ ] White/Caucasian
- [ ] Other
- [ ] Decline to State

41. Are you an English Language Learner? *

Mark only one oval.

- ◯ Yes
- ◯ No

42. How many languages are spoken in your home including English? *

Mark only one oval.

- ◯ English is not spoken in my home
- ◯ Only English
- ◯ English and 1 other language
- ◯ English and multiple other languages

43. Gender Identity: How do you describe yourself. Mark only one response: *

Mark only one oval.

- ◯ Female
- ◯ Genderqueer/Gender Non-Conforming
- ◯ Male
- ◯ Non-Binary
- ◯ Transgender
- ◯ Other
- ◯ Decline to State

44. What is the highest level of education completed by your parents or guardians? *

Mark only one oval.

- ◯ Some high school
- ◯ High school graduate, diploma or the equivalent (such as GED)
- ◯ Some college credit, no degree
- ◯ Associate degree (community college) or trade/techincal/vocational training
- ◯ Bachelor's degree
- ◯ Master's degree
- ◯ Doctorate or Professional Degree
- ◯ Prefer not to answer or degree unknown

45. Would you be interested in participating in a follow up interview during school so our counselors, our math teachers and our administrators can learn more about your experiences in math classes at WHS? We are able to offer snacks during the interview as a thank you for your time and will coordinate with you of which class period is ok for you to miss for the interview. *

Mark only one oval.

- ◯ Yes *Skip to question 46*
- ◯ No

Follow up Interview

46. What is your name so Assistant Principal Krasnow can contact you for a follow up interview? If you prefer not to have your name associated with these survey results, you can also email her.