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# Mindset, Stereotype Threat, and the Fear of Failure: Why Female Students Leave a Secondary High Honors Mathematics Pathway

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# MINDSET, STEREOTYPE THREAT, AND THE FEAR OF FAILURE: WHY FEMALE STUDENTS LEAVE A SECONDARY HIGH HONORS MATHEMATICS PATHWAY

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# DEDICATION

This study is dedicated to Dr. Emily Silverman, who has cared about this problem of practice since she started teaching at this school and was always willing to sit down and talk to me about what is happening and what we can do. Emily is always intentional about her decisions and so often they are backed by data she has collected and analyzed herself over the course of her career; it's inspiring. I hope that this dissertation finally helps us gain the support we need to make real changes for these female students.

This study is also dedicated to Rosie Pfenning, who has been an incredible mentor and role model for me—as a former science teacher turned math teacher—because she is the type of teacher that makes math class both interesting and challenging. Plus, she enthusiastically shows girls that being a nerd is a compliment.

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At the study site, Sarah DiGiacomo and Dr. Emily Silverman provided crucial quantitative data that only existed because they personally collected and organized it; the district itself does not track or keep this data at all. Without them, the results of this study would have been significantly less meaningful. I'd also like to thank Diana Rapp who has always been my cheerleader at work—reminding me that this work is important for our students and encouraging me when the problem of practice felt overwhelmingly large.

Finally, I would like to thank my partner, Dylan, who was motivating through the entire program, especially when I needed it the most. His support was boundless and compassionate, making every day a better version of what it would have been without him.

# ABSTRACT

The disproportionate attrition of female students in STEM is well documented in higher education but less well understood at the secondary level. In a large, public high school in an affluent, highly educated city, the high honors mathematics pathway is the only math pathway that has not yet achieved gender parity, an implication for future educational and economic equity. Female students leave this pathway at significantly higher rates than male students, especially during and immediately after the first course. Through an explanatory, mixed methods approach, this study found that these female students are not less well prepared than their male peers but they instead use psychological factors to justify their decision to leave—factors related to mindset, stereotype threat, and a fear of failure. These factors include extremely high academic expectations, low self-confidence, increased stress, perfectionist tendencies, outside pressure, and a low intrinsic interest in mathematics-related fields. These results and findings inform recommendations for practice and future research.

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ACC ........................................................................................Anterior Cingulate Cortex

AP ..............................................................................................Advanced Placement

GPA ...........................................................................................Grade Point Average

IB .....................................................................................International Baccalaureate

RQ1 ........................................................................................... Research Question 1

RQ2 ........................................................................................... Research Question 2

SAT ....................................................................................... Scholastic Aptitude Test

STEM............................................... Science, Technology, Engineering, and Mathematics

# CHAPTER 1

# INTRODUCTION

Meet Johnny and Jenny. They are both high-performing freshmen students in an honors mathematics course at Crescent High School, a course typically taught to sophomores. Johnny is a good student. He does the homework with diligence and attention to detail; he occasionally asks questions about challenging problems. Emotionally, Johnny is even-tempered and outwardly seems unaffected by academic stress. On assessments, he scores well above average. Jenny, on the other hand, is an exceptional student. Each of her homework assignments exceeds expectations; she is meticulous and clearly spends a lot of time and effort on her work. When Jenny has a question, she pursues the answer relentlessly, no matter how small. Despite frequent stress-induced proclamations that she "totally failed the test," Jenny scores at the top of the class.

In the spring, teachers use these assessment scores to recommend students stay in the same honors pathway or accelerate an additional year to the first class of the high honors pathway. The high honors pathway is rigorous and the first class has the reputation of being extremely challenging—often the first difficult math class the students have taken. Thus, students must learn how to be good students—studying for tests, balancing extracurriculars, and coping with setbacks. Many math teachers believe that freshmen, who have fewer of these student skills, exaggerate the course's reputation.

Nevertheless, Johnny and Jenny have friends in the high honors pathway and hear stories about what it is like.

When teachers give course recommendations for the next year at Crescent, they sit down with each student one-on-one, give the recommendation based on assessment scores, and talk about the student's questions and academic goals. This is where a surprising pattern emerges. Every Johnny recommend to the high honors pathway eventually enrolls in the course without expressing concern. Some other male students who did not earn the recommendation also override and enroll in the higher course. However, a *majority* of the female students express fear and self-doubt about their ability to succeed in the higher course, despite doing exceptionally well in mathematics so far. Only half of them end up enrolling in the high honors pathway. Because many of the top female students seem to have better work ethic, organization, and a willingness to ask questions—three salient student skills—the difference in attitude and confidence between the male and female students seems both shocking and unjustified. The girls' stress and concern does not match their academic performance.

Students' enrollment decisions impact the demographics of the high honors pathway. Even though female students account for 52% of the student body at Crescent, only 44% of the first course of the high honors mathematics pathway are female. Throughout each course, this proportion decreases until, in the final courses in the pathway, only 23% of the students are female. This pattern is longitudinal and systemic, yet most research on attrition of women in STEM has been conducted at the university level. Understanding the causes of the disparity at Crescent is vital to design an intervention that considers the specific needs of these students and this community.

Therefore, this study aimed to better understand the female students' experience in the high honors pathway at Crescent High School by discovering out when and why they leave.

## Problem of Practice

Female students leaving the high honors mathematics pathway is a problem, not only for educational equity but also for economic equity. According to de Brey et al. (2019), despite the fact that 58% of all bachelor's degrees are conferred to women, women earned only 36% of bachelor's degrees in STEM fields. Additionally, women with STEM degrees are more likely than their male counterparts to pursue careers outside of STEM. These two realities—that women earn fewer STEM degrees and when they do they are less likely to pursue STEM careers—gives rise to the disparity in the U.S. workforce where despite filling 48% of the total jobs, women hold only 27% of the jobs in STEM fields—a number that has not changed since 2000 despite women increasing their share of the workforce (Martinez & Christnacht, 2021). This career disparity causes economic disparity as graduates with STEM degrees tend to have more positive economic outcomes. For example, people with STEM degrees make $15,500 more annually on average than graduates with non-STEM degrees (de Brey et al., 2019). Even the gender pay gap is different. Women in STEM fields make 14% less than their male counterparts while women in non-STEM fields make 21% less than their male counterparts (Beede et al., 2011). This means that women with STEM careers earn 33% more than comparable women in non-STEM careers.

Each one of these disparities—in education, the workforce, and economics—is more extreme in engineering, mathematics, and computer science. These fields require

higher-level mathematics than biological sciences or health sciences, suggesting that the higher the level of mathematics that a field requires, the more pronounced the disparity. This makes sense given that mathematics is often cited as the gatekeeper to STEM degrees (Cobb & Hodge, 2011; Stinson, 2004). As such, achieving parity in STEM fields requires parity in mathematics. Moses and Cobb (2011) argue that "math literacy—and algebra in particular—is the key to the future of disenfranchised communities," (p. 5) and that access to advanced mathematics is a civil right that both parents and students should demand as a way of achieving economic equity.

While attrition of female students in STEM degree pathways is well documented (Seymour & Hewitt, 1997; Seymour & Hunter, 2019), attrition of female students in high school mathematics is less understood. Approximately 44% of the students enrolled in the first class of the high honors pathway are female. Just four years later, only 23% of the students enrolled in the last class of the high honors pathway are female. More female students decide to leave the pathway than their male peers, a decision that affects their academic, career, and economic goals and opportunities.

Root causes of this disparity are more difficult to pinpoint than the disparity itself. At the college level:

> When men drop out of quantitative majors in college, it is usually because they have bad grades. When women drop out of quantitative majors in college it usually has nothing to do with their grades. The culprit, in their case, is not their quantitative skills but, more likely, the prospect of living a significant portion of their lives in a domain where they may forever have to prove themselves—and with the chronic stress that goes with that. (Steele, 2010, pp. 111–112)

This finding, conversations with students and colleagues, and other literature on this phenomenon suggest three main causes that contribute to the attrition of female students in the high honors pathway at Crescent: mindset, stereotype threat, and the fear of failure. Although these three causes are well documented in the literature, the extent to which each affects this particular community is unclear.

**Theoretical Framework**

The theoretical framework of this study is threefold—one for each of the hypothesized causes of the pattern of disproportionate attrition of female students in the high honors mathematics pathway (Figure 1.1).

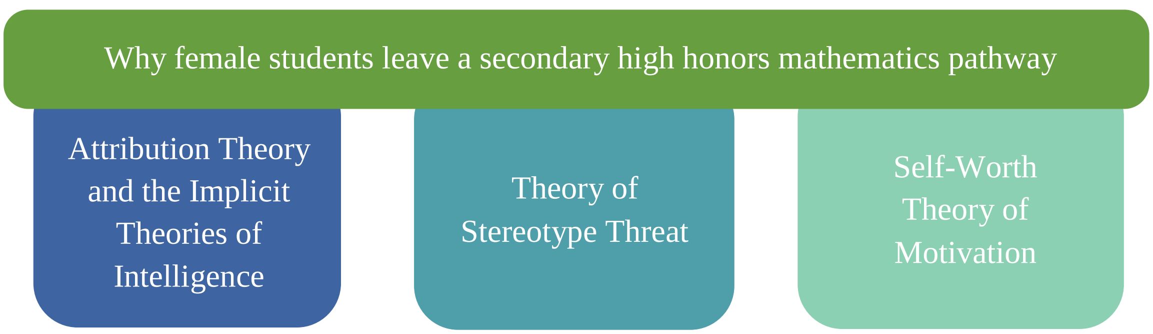


**Figure 1.1** *Theoretical Framework*

First, attribution theory and implicit theories of intelligence best encompass how mindset can impact attitudes, behavior, and identity in mathematics. Attribution theory links a person's confidence with how they attribute success or failure. According to Reyes (1984), students who attribute success to higher ability may have more confidence. This confidence empowers them to take risks when problem-solving. However, when students reach an impasse, they may believe they lack the ability for the task and therefore quit early. Kloosterman (1988) found that students with high confidence

attributed success to high ability and failure to lack of effort. Students with low confidence, however, attributed failure to lack of ability.

Implicit theories of intelligence developed from attribution theory but encompass more than just how students attribute success and failure; they define how an individual views intelligence. The two implicit theories of intelligence, *entity theory* and *incremental theory,* suggest the beliefs of the individuals who hold them. Entity theorists believe intelligence exists as an entity—that intelligence is innate. In contrast, incremental theorists believe intelligence accrues incrementally—that intelligence is learned. Outside of social psychology, Dweck (2006) refers to entity theory as a "fixed mindset" and incremental theory as "growth mindset." In keeping with the shift in the educational literature to these more generalized terms, Dweck's phrases will be used exclusively from here.

Despite the importance of mathematics, many students find the content difficult. Dweck (2006) explored how students with growth mindsets can better rise to the challenge of the struggle. A student with a growth mindset believes ability can improve through hard work. They see challenge as necessary to achieving success and thus are more likely to persevere through difficult problems. In contrast, a student with a fixed mindset believes ability is innate. They see challenges as an indicator that they are not good at the task and thus are less likely to persevere through difficult problems. Female students are more likely to have a fixed mindset and therefore less likely to pursue mathematics as they encounter challenges (Boaler, 2016; Boaler & Sengupta-Irving, 2006; Dweck, 2007). This disparity is especially true for high-performing female students (Boaler & Sengupta-Irving, 2006; Licht & Dweck, 1984).

Secondly, stereotypes can also impact achievement. Benbow and Stanley (1980) attributed gendered differences in mathematics test scores to biological differences—a prevalent stereotype of women in mathematics. However Steele (1997) ascribed this same disparity to "stereotype threat," a phenomenon that occurs when a portion of a person's cognitive load is devoted to being anxious about perpetuating a negative stereotype of a group in which they are a member, instead of the task at hand. Students do not have to be reminded of the stereotype; they assume it is true without being told (Spencer et al., 1999). Stereotype threat requires three things: (1) the person must be aware of the stereotype, (2) the person must care about doing well, and (3) the task must be challenging (Aronson et al., 1999).

Stereotype threat happens at a crucial time in development—the first true challenging material. For many students who have coasted through middle school mathematics, the courses in the high honors pathway are often the first challenging moments. This is when students decide if they want to continue to put forth effort in the subject, which could explain why the attrition of female students happens in the highest-level mathematics pathway but not the second highest.

Finally, the fear of failure and its impact on academics falls within the scope of the self-worth theory of motivation. Adapted from the aforementioned attribution theory, self-worth theory assumes students construct their achievement goals to maintain a sense of worth in a society that values competency and success (Covington, 1992). They view themselves as only as worthy as their ability to achieve. For some students, defining success as becoming the best version of themselves, regardless of the achievements of others, can be positive and motivating (Covington, 1992). For students who define

success as doing better than their peers academically, exhibiting self-worth theory can be debilitating as students are "forced to avoid failure, or at least avoid the implications of failure… because the rules of competition dictate that only a few can succeed" (Covington, 2000, p. 181). This latter case likely applies to the students in this pathway; Crescent has an intensely competitive academic culture where many students openly discuss the pressure they feel to do better than those around them.

Students who marry their self-worth to academic achievement can develop defensive mechanisms built on their fear of failure (Fried-Buchalter, 1992; Thompson et al., 1998), one of which is defensive pessimism. When students employ this strategy, they maintain low expectations for themselves in an effort to avoid failure and the feelings of anxiety that would undoubtedly arise if they took the task seriously (Covington, 2000). By lowering the bar, they lower their risk of failure, even if the risk was minimal. Although defensive pessimism affords short-term protection from failure, significant long-term effects can include inconsistent achievement, emotional exhaustion, burnout, and reduced interest in achieving overall (Thompson, 1994).

In summary, attribution theory and the implicit theories of intelligence, stereotype threat, and the self-worth theory of motivation distinguish the underlying impact of mindset, stereotypes, and the fear of failure respectively.

**Purpose of the Study, Research Questions and Rationale**

The goal of this study is to discover when and why female students leave the high honors mathematics pathway so that an effective, sustainable change that addresses the problem of practice can be designed and implemented by interested educators and

administrators. The theoretical framework of this study is built on the three hypothesized primary causes of this problem and inform two research questions:

- Research Question 1 (RQ1)*:* In a large, public high school in an affluent, highly-educated city, when do female students leave the high honors mathematics pathway?
- Research Question 2 (RQ2): Why do female students leave the high honors mathematics pathway?

RQ1 is important for identifying any chronological patterns in the pattern of attrition at Crescent High School. Is the attrition rate the same for all courses? Does a specific course in the pathway have a higher rate of attrition? Understanding the quantitative pattern in the enrollment data guided the data collection for RQ2. For example, one course has a higher rate of attrition than the others therefore data collection for RQ2 focused on this time period to identify why the rate of attrition for this course is higher. Understanding any chronological patterns also guided recommended policy changes and interventions as targeting courses with higher attrition is likely to make the most impact.

RQ2 is the main focus of the study, hence the strong connection to the theoretical framework, and illuminated how female students experience the high honors pathway and what events, emotions, and pressures push these students to leave. Existing literature documents many potential causes for higher education, yet very little research has investigated why secondary female students leave advanced mathematics pathways. Designing a more successful and long-term solution requires identifying the causes of the problem of practice.

**Researcher Positionality**

As a practitioner researcher, I am an insider, which has many benefits. My tacit knowledge of my students, classroom, and community allowed me to quickly recognize the problem of practice and develop a list of potential causes. However, "tacit knowledge of a site tends to be impressionistic, full of bias, prejudice, and uninterrogated impressions and assumptions that need to be surfaced and examined" (Herr & Anderson, 2015, p. 44). As the classroom teacher of many of these students, I am not objective. Unlike an outside researcher, I am more inherently invested in the results of this study because I care directly about these students and this problem of practice.

One of my primary biases is how this problem of practice has affected my own life. When I was young, adults praised my intelligence rather than my effort. Because my engineer father taught me math skills, most of elementary school mathematics was a review and therefore easier for me than it was for my peers. My teachers, who did not know my background, reiterated that I was talented in mathematics. In keeping with attribution theory, I was very confident in mathematics from a young age. To me, intelligence was innate—I possessed a textbook fixed mindset, which influenced how I viewed studying, setbacks, and peers who worked harder than I did. My self-worth was entwined with my grades. Years of gradual challenge and an intense academic goal kept me motivated while protecting my self-confidence. Because of these experiences, I strongly believe that mindset and self-worth influence confidence in mathematics. If I had experienced significant academic challenges early on, I could have been crippled by the fear of failure. On the positive side, I also know that with years of concentrated effort, a true mindset shift can happen; therefore, I see this study as a catalyst for change rather

than the be-all-end-all solution. My hope is that the information gleaned from this research will better inform the next steps toward mitigating the problem of practice.

I have also experienced stereotype threat and deeply felt the impact of tokenism on my academic performance. During my master's program, I took a science course and was the only female student in a lecture of about 150. While I doubted that my male professor and male peers recognized this imbalance, I was instantly aware the moment I walked into the classroom; I still remember that feeling. Stereotype threat fueled my motivation to do as well as possible; I was consciously mindful that my performance could reflect on the academic potential of all women. Had the course been more challenging, I believe this self-monitoring behavior could have hindered my cognitive load during assessments and negatively impacted by performance.

Demographically, I am very similar to many of my students; I am a White woman who grew up in an upper middle-class family. Both my parents have bachelor's degrees, and they chose my hometown because of the strong academic reputation of the school system. These similarities are an advantage because I better understand many of these students' motivations, pressures, and cultural backgrounds. The bias emerges if I assume that *all* students with these shared demographics have the same concerns, values, and experiences with each other and with me.

I am also different from specific groups of students. Most of the students in this pathway are male and they may understand their mathematical abilities and mindset differently than the female students. Many of the students in this pathway are also Asian or both Asian and White and their experiences thus differ from mine. For example, one of my female Asian students once told me how much pressure she feels to do well in

mathematics because of her race. Having never felt this pressure, I cannot empathize with it fully. Some students in this study are from other countries or have parents who are from other countries. Their cultural experiences may have affected their confidence in mathematics in ways I do not understand. Additionally, a few students have a documented learning disability and some receive free or reduced-price lunch. I am an outsider to all of these experiences. This ignorance can create biases if I make unexamined assumptions or use stereotypes to interpret results.

Another potential bias emerges from school culture. My school, though touted for its academics, was laidback compared to this school. Crescent has an extremely strong academic reputation. In 2019, two students won the International Science Fair in their categories and 10% of the seniors were National Merit semifinalists. Admission into schools like Harvard, Stanford, and MIT happen every year. Students are vocal about the competitive pressure they feel to be the best. Former students who did well in the high honors mathematics pathway have told me they felt that they were not good at mathematics despite strong evidence to the contrary. Crescent seems to have an environment where students feel if they are not the best, they are not good enough. Because this is so different than my own experience, I can sometimes underestimate the academic stressors on my students and find their harsh self-judgments to be angsty rather than legitimate. This bias might then impact how I interpret the data or how willing students are to share these concerns in my presence.

Overall, despite any similarities or differences in my life and the lives of my students, I care deeply about the outcomes of this study and believe that what these

students feel is their reality. This is a problem of practice about which I am passionate; encouraging more girls to choose STEM is literally why I became a math teacher.

**Research Design**

This is an explanatory sequential mixed methods action research study. Action research is appropriate because this is an investigation conducted by an educator in their own setting (Efron & Ravid, 2013). According to Herr and Anderson (2015), the knowledge generated in action research—knowledge that addresses immediate needs of people in specific communities—is one of its major strengths. This approach aligns with the purpose of this study: to better understand the female students in this community to create a specific change or intervention targeted to their unique and specific needs to yield the most effective and sustainable change possible.

This study also used an explanatory sequential mixed methods approach (Creswell & Plano Clark, 2018), drawing on the different strengths of both qualitative and quantitative design. Quantitative data were collected first to answer RQ1 and establish the pattern for when female students are leaving the high honors pathway; then quantitative and qualitative data explained why these students are leaving.

Quantitative descriptive research methods can best answer RQ1 by supplying an objective measurement to track student enrollment in the high honors mathematics pathway. The quantitative results guided the design and implementation of the mixed methods approach used to answer RQ2. The rate of attrition was not constant; therefore, the data collection for RQ2 and recommendations for practice were oriented toward the course with the highest rate of attrition.

Qualitative, phenomenological methods are irreplaceable in answering RQ2. The core of this research question is the assumption that female students must have a different and more negative experience in the high honors pathway than the male students. If they did not, such a disparity likely would not exist. Therefore, understanding the essence of being a female student in the high honors pathway is vital, which called for a qualitative approach seeking to understand how students make sense of their experiences (Efron & Ravid, 2013). More specifically, this study incorporated elements of phenomenology, "best suited to studying affective, emotional, and often intense human experiences" (Merriam & Tisdell, 2016, p. 28), to develop a basic structure of the female experience in the high honors pathway. Quantitative methods were also used to answer RQ2 because some measures of achievement and mindset can be objectively measured.

This explanatory sequential mixed methods action research study took place in a large, public high school in an affluent, highly-educated city. The participants of the quantitative facet of this study included two samples: (a) all students enrolled in the high honors mathematics pathway between 2012 and 2022 and (b) students who entered the first course of the high honors pathway in 2018, the 2018 Cohort. The second sample was needed because the longitudinal data did not include demographic information about the students. The 2018 Cohort was the most complete recent group of students for which demographic information was available. In addition to enrollment and achievement data, this study used surveys and semi-structured interviews with a sample of students who left the high honors pathway during or immediately after the 2021 fall semester.

## Data Collection and Analysis

The types of artifacts collected during this study varied based on the research question. Quantitative artifacts used to answer RQ1 include longitudinal enrollment data and enrollment data for the 2018 Cohort. Quantitative artifacts used to answer RQ2 include diagnostic scores and first semester grades for the 2018 Cohort in their first year of the high honors pathway, diagnostic scores from an experimental procedure investigating the effects of stereotype threat, scores on a mindset quiz from Dweck (2006), and results from a survey about factors respondents considered when deciding to leave the pathway.

Qualitative artifacts used to answer RQ2 include open-ended data with protocols, specifically transcribed semi-structured interviews with select female students who left the high honors pathway during or immediately after the 2021 fall semester. Collection and analysis of this interview data occurred simultaneously, using findings to tailor subsequent interviews toward any thematic patterns that emerged from the data.

## Significance and Limitations of Study

This study is significant for two reasons. First, even though educational settings are unique and this study will not predict consistent results across all environments, other settings that have observed a similar problem of practice in a similar setting could find the results and findings useful. This outcome is one benefit of action research in general: "while [it] is seldom statistically generalizable, the knowledge [action research] generates can be transferred beyond the research setting" (Herr & Anderson, 2015, p. 6).

Second, this problem of practice is well documented in higher education (de Brey et al., 2019; Seymour & Hewitt, 1997; Seymour & Hunter, 2019) but significantly less so

at the secondary level. This gap in the literature makes designing effective and sustainable policy changes and interventions more difficult. The intended audience for this study is the teachers and administrators of Crescent High School and its district because improving local understanding of the phenomenon can enable the community to address the inequity. However, high schools with similar patterns in their mathematics pathways, not only for female students but other groups of students, might find this study helpful. At the very least, the methods described here can give researchers with similar problems of practice a place to start their own investigations.

Despite this hope, a significant limitation of this study is the specificity of this particular school, reflecting one of the limitations of action research in general:

> Generalization of the findings to other settings cannot be done with a high degree of confidence, because of the small size…, the limitations in selecting a representative sample of participants, and the tenuous control practitioners have over the variables in the study. (Efron & Ravid, 2013, p. 49)

Consistent with this limitation, some of the sample sizes were small. The longitudinal enrollment data did not include demographic information, necessitating a smaller sample to establish the attrition pattern for female students. Additionally, only the 16 students who left the high honors pathway during or immediately after the 2021 fall semester took the pathway exit survey, reducing the reliability and validity of the results. The experiment investigating the impact of stereotype threat also had a significant limitation: because it was designed before the diagnostic scores of the 2018 Cohort were examined, it did not examine the most likely effect of stereotype threat in this sample.

The final limitation is my position as an insider. My own biases, personal experience, and motivation could have influenced the way I identified themes in the interviews. My relationship with some of these students could also have impacted how comfortable they felt answering questions honestly in the interviews. An outside researcher would have been more objective.

**Organization of the Dissertation**

Chapter 2 summarizes the background literature, including how it explains the problem of practice, informed the design of the study, and justified its significance. In Chapter 3, the methodology of this study is discussed in greater detail, not only the design but also the rationale for the data collection and analysis. In Chapter 4, the results and findings are presented, summarized, and analyzed. Finally, in Chapter 5, the results and findings are connected to the background literature and used to make recommendations for practice and future research.

# CHAPTER 2

# LITERATURE REVIEW

At a large, public high school in an affluent, highly-educated city, female students leave the high honors mathematics pathway at disproportionally higher rates than their male peers. This attrition pattern also appears in higher education and the workforce, where women are underrepresented in STEM degree programs and even more underrepresented in STEM fields (de Brey et al., 2019; Martinez & Christnacht, 2021). Attrition gaps have significant consequences for both educational and economic equity. Addressing attrition in mathematics pathways is especially paramount as mathematics is heralded as the gatekeeper to STEM degrees (Cobb & Hodge, 2011; Stinson, 2004). This banner statement is supported by the differential disparities within each of the STEM disciplines; the more high-level mathematics a field requires, the more pronounced the disparity (de Brey et al., 2019). Therefore, achieving parity in STEM requires parity in mathematics.

However, identifying exactly how to achieve parity in mathematics at a high level is complex and significantly more difficult to accomplish than analyzing the disparity itself. Seymour and Hewitt (1997) analyzed qualitative interviews and quantitative enrollment data to conclude that disproportionate attrition of female students is due to a combination of academic and non-academic factors; a single factor like academic performance or gender discrimination cannot fully explain the pattern. Identifying the

combination of factors unique to this community is vital to addressing the problem of practice in a meaningful and effective way.

### Purpose of the Study and Research Questions

Over the last three decades, many underlying causes of this phenomenon have emerged, each with their own interventions designed to target a single cause (Blackwell et al., 2007; Good et al., 2003). While the success of these interventions suggests causal relationships, the time and resources necessary to implement and analyze the efficacy of these interventions is limited in secondary public schools. As such, understanding the unique manifestation of this phenomenon in this community must precede any action. Based on the literature and an insider position within the community, three causes stand out as the most probable: mindset, stereotype threat, and a fear of failure. Other potential causes include mathematical anxiety, implicit bias, and peer effects.

The theoretical framework of this study is built upon these causes and informed the research questions:

- RQ1: In a large, public high school in an affluent, highly-educated city, when do female students leave the high honors mathematics pathway?
- RQ2: Why do female students leave the high honors mathematics pathway?

Each of the three causes—mindset, stereotype threat, and a fear of failure—are hypothesized answers to RQ2 and all three are linked to achievement, motivation, and attrition in general.

### Female Attrition in STEM

Despite their improved and often superior level of achievement, female students are more likely to voluntarily avoid taking advanced math courses in high school

(Herbert & Stipek, 2005; Trusty et al., 2000) or leave the discipline sooner (Herzig, 2004). They are also less likely to choose STEM electives in high school (Xie & Shauman, 2003). At the university level, fewer women initially major in STEM as freshmen and a higher percentage of them leave the discipline entirely for other non-quantitative fields (Seymour & Hunter, 2019). Some researchers also express concern that the female students who left STEM majors were disproportionately able in that they had higher high school GPAs than their non-STEM majoring peers (Green, 1989).

As to *why* this happens, prior to 1990, research seldom explored factors that contribute to student attrition or investigated these factors for disparities in gender, race, and ethnicity (Seymour & Hewitt, 1997). Early studies with nonspecific questions yielded more questions than answers and faculty opinion surveys skewed qualitative research toward achievement factors like poor prior preparation. Studies of actual student experiences were rare (Seymour & Hewitt, 1997) and even now, the majority of studies on gender and mathematics involve college students (Erchick, 1996; Herzig, 2004).

One argument to explain the disproportionate attrition of women in STEM derives from discussions of the gender achievement gap in STEM. Despite the overall gender achievement gap decreasing over the last 4 decades, a large and persistent gender gap favoring male students persists among groups of top-achieving students and in affluent, highly-educated, predominantly White school districts like Crescent’s (McGraw et al., 2006; Reardon et al., 2019). Achievement is a salient factor in examining why female students leave quantitative fields because studies have shown that female students are more affected by grades than their male peers and more likely to leave programs in response to perceived poor academic performance (Kugler et al., 2017; Ost, 2010).

Explanations for this gap in performance are diverse and nuanced. The first, and rather persistent, explanation was biology; some researchers interpreted the achievement data as evidence of women's and girls' inherent, genetic inability to perform well on quantitative tasks (Benbow & Stanley, 1980; Benbow et al., 2000). Arguments that spatial reasoning is finite and varies by gender also contributed to these biological claims (Hedges & Nowell, 1995). One contradiction to this explanation is that achievement alone does not explain attrition; some women major in STEM fields initially but eventually leave for non-quantitative fields even when their achievement is the same as their male peers' (Beasley & Fischer, 2012; Seymour & Hewitt, 1997; Seymour & Hunter, 2019).

Researchers started exploring psychological mechanisms that would explain both achievement and attrition. The first clues came from a series of studies that investigated the daily experiences of female students, faculty, and administrators in the sciences (Hall & Sandler, 1982, 1984, 1986). The authors pronounced the women's experiences to be "chilling," describing rudeness, disattention, and overt discrimination. Messages of lower expectations for women prompted high-achieving women to lower their academic and career ambitions and underachieve. Around this same time, the Illinois Valedictorian Project followed the college progress of 80 high school seniors of high ability and found significant attrition by sophomore year of previously high self-esteem female students who had decreasing career ambitions despite high performance (Widnall, 1988). The male students in this cohort reported increased self-esteem and ambition over the same time period. This body of research culminated in Seymour and Hewitt's (1997) seminal work *Talking about Leaving: Why Undergraduates Leave the Sciences*. The authors interviewed hundreds of students in STEM degree programs across the country and found

serious psychological implications of inequity; female students reported psychological alienation and lower self-esteem as two significant factors in their decision to leave STEM degree programs (Seymour & Hewitt, 1997). Over a decade later, Seymour and Hunter (2019) found many of the same results and findings. Female students reported a higher loss of confidence in their first year STEM courses than their male peers and identified this factor as one of the most influential in their decision to leave their STEM degree program.

Researchers still investigate hostile experiences (Blickenstaff, 2005) along with other environmental factors like the lack of female role models (Bagès et al., 2016; Fischer, 2017; Lim & Meer, 2017) and absence of high-achieving female peers (Hoxby, 2000; Lavy & Schlosser, 2011). However, most contemporary explorations investigate underlying psychological motivations like mindset, stereotype threat, and the fear of failure, as well as mathematical anxiety, implicit bias, and peer effects. These psychological factors inform the theoretical framework of this study.

**Mindset**

Mindset is the tendency toward the belief that intelligence is either a fixed, predetermined character trait or a malleable process that can develop through practice and persistence and it reflects a person’s perspective on intellectual ability (Degol et al., 2018; Dweck, 1986). This section discusses the history of the concepts of fixed and growth mindsets, followed by connections to achievement, motivation, and attrition, with particular emphasis on female students in mathematics.

***History and Theoretical Background***

Although Dweck (2006) popularized mindset in *Mindset: The New Psychology of Success*, its origins date back much further. Binet, a French psychologist who pioneered the first IQ test, asserted that intelligence was not fixed and was defined in terms of attitude (Varon, 1936). Later, Weiner (1985) and Dweck (1986) proposed the two theoretical scaffolds of mindset: attribution theory and the implicit theories of intelligence respectively—each with their own histories.

**Attribution Theory.** In education, this theory of motivation and emotion describes how causal attributions of academic success and failure can influence expectancy and value of success and therefore behavior (Weiner, 1985). Examples of causal attributions include luck, effort, ability, interest, and clarity of instruction, among others. In achievement contexts, Weiner (1985) found three common properties in these causes: locus (internal/external), stability (causes can/cannot change over time), and controllability (can be controlled/cannot be controlled). While stability influences changes in expectancy of success or failure, all three properties modulate common emotional experiences like anger, hopelessness, pride, and shame. For example, when a student succeeds academically, they often attribute their success to an internal cause, like their own ability or effort. However when a rival succeeds, the same student often attributes this other person’s success to an external cause, like luck; this pattern reverses when describing causes of failure (Woolfolk, 2007). These attributions can influence affect, which then guides motivated behavior (Weiner, 1985).

**Implicit Theories of Intelligence.** The implicit theories of intelligence developed from attribution theory and characterize how an individual understands the nature of

intelligence. The two implicit theories of intelligence form two poles on opposing sides of a spectrum: entity theory or fixed mindset on one side and incremental theory or growth mindset on the other (Dweck, 1986). The names of these theories reveal how individuals view intelligence—either as a complete, fixed entity or an incremental growth based on practices and experiences.

Individuals with more of a fixed mindset believe they have a certain amount of intelligence or ability and cannot do much to change it (Haimovitz & Dweck, 2017). They believe that the ultimate goal of learning is to demonstrate high intelligence through assigned performance standards (Dweck, 1986). Those with a growth mindset, on the other hand, believe they can improve their intelligence or abilities through hard work, adaptive strategies, and support from others (Blackwell et al., 2007; Dweck & Leggett, 1988). They are therefore more likely to endeavor toward personal learning or improvement goals (Dweck, 1986; Yeager & Dweck, 2012). In mathematics, for example, a student with a fixed mindset may see success as achieving an A on an exam while a student with a growth mindset may find success in discovering a new way to solve a problem.

Implicit theories of intelligence influence how students understand goal-setting and effort and modulate their reactions to failure (Blackwell et al., 2007; Cury et al., 2006; Dweck & Leggett, 1988; Haimovitz et al., 2011). Through these influences, mindsets create different pathways for learning and motivation (Burnette et al., 2013; Plaks et al., 2009; Yeager & Dweck, 2012).

***Mindset and Achievement***

Yeager and Dweck (2012) theorized that fixed mindsets can undermine academic performance while growth mindsets improve academic performance and promote more adaptive approaches to learning. These connections are corroborated in the literature, where the development of a growth mindset is associated with higher academic achievement (Blackwell et al., 2007; Romero et al., 2014) and suggestive of future academic performance (Boaler & Sengupta-Irving, 2006). For example, Claro et al. (2016) surveyed tenth-grade students in Chile and found a significant positive correlation between having a growth mindset and national standardized test scores; the more a student ascribed to a growth mindset, the better they performed. This pattern held for all levels of socioeconomic status.

Most importantly, many researchers have shown that students who participated in mindset interventions to develop growth mindsets started performing better in school, sometimes immediately (Blackwell et al., 2007; Claro et al., 2016; Cury et al., 2006; Good et al., 2003; Stipek & Gralinski, 1996; Yeager et al., 2016). These findings suggest mindsets have a causal relationship with achievement, which has significant implications for inequity as female students are more likely to have aspects of a fixed mindset (Boaler, 2016; Boaler & Sengupta-Irving, 2006; Dweck, 2007). This is especially true for high-achieving girls (Boaler & Sengupta-Irving, 2006; Licht & Dweck, 1984).

In one seminal study, Licht and Dweck (1984) examined how students coped with confusion. This study provides insight into mathematics performance because confusion is more common in quantitative subjects than verbal subjects because new material often introduces completely new skills and concepts (Dweck, 2007). The researchers

introduced a new task for students to learn, placing purposely confusing material near the beginning for half the students. What they found was striking; in the confusion manipulated group, the higher the girl's IQ, the *worse* she did on the task. Many of the girls were unable to learn the task at all. The boys in the confusion manipulated group demonstrated the opposite pattern: the higher the boy's IQ, the better he did. A surprising facet of the results is the students' age; the students were in fifth grade during the study, an age where girls are still outperforming the boys academically in nearly every subject. Moreover, the task was not mathematical, so stereotypes about girls in mathematics was not a contributing factor.

Thus, a student's motivational beliefs are highly predictive of achievement only when challenging material is present and success is difficult (Grant & Dweck, 2003). Because high-achieving girls are more likely to have fixed mindsets, they are more vulnerable to a loss of effectiveness when they encounter challenging material, a hallmark of high-level math. Research has even shown that when female students *do* have a growth mindset, they outperform their male peers (Degol et al., 2018).

### *Mindset and Motivation*

Mindset is linked to motivation in that it frames how a person views learning, challenges, mistakes, and feedback (Dweck & Sorich, 1999). Achievement is an important factor in attrition but so is the perception of achievement (Seymour & Hewitt, 1997; Seymour & Hunter, 2019). Students with a fixed mindset are more likely to equate success and failure to ability (Dweck, 1986). When faced with challenging material, a fixed mindset may reduce perceptions of ability and therefore reduce expectancy for success in the future (Burnette et al., 2013; Komarraju & Nadler, 2013). On the other

hand, students with more growth mindsets equate success and failure, not to ability, but to effort and practice (Dweck, 1986). These students, therefore, are more likely to welcome and persist through difficult material, use proactive coping strategies, and have higher expectancy of success (Burnette et al., 2013; Doron et al., 2009).

The evidence for female students' having lower expectancy for success in mathematics is robust (Burkley et al., 2010; Degol et al., 2018; Dweck, 2007; Else-Quest et al., 2013; Herbert & Stipek, 2005) and according to attribution theory, expectancy for success guides behavior (Weiner, 1985). This behavior manifests as avoiding challenging problems altogether and engaging in maladaptive self-protection strategies (Burnette et al., 2013; Doron et al., 2009).

Because female students, and especially high-achieving female students, are more likely to have fixed mindsets and lower expectancy for success, their responses to success and failure are more likely to negatively affect their behavior. Cramer and Oshima (1992) found that high-achieving female students in ninth grade reported more "self-defeating" causal attributions for mathematics performance compared to their high-achieving male peers. The girls attributed failure to ability while the boys attributed failure to effort. The gender differences were less pronounced with average students. These results are congruent with other findings (Else-Quest et al., 2013; Herbert & Stipek, 2005). Dweck (2006) summarized the phenomenon:

> It's here, at the top of the ability distribution, that the gender difference in math emerges. Thus, it is possible that at least part of the emerging difference in math is a gender difference in coping with setbacks and confusion rather than a gender difference in math ability. (p. 48)

Beyond motivation regarding success and failure, mindset is also important in understanding other motivations, like intrinsic interest and enjoyment. For example, when facing challenging material, students with fixed mindsets often worry about *appearing* unintelligent or incompetent, a worry that can impede performance in the task itself but also intrinsic interest and enjoyment (Dweck, 1986; Stipek & Gralinski, 1996). Research shows that setting personal learning goals, indicative of a growth mindset, is associated with greater intrinsic interest and enjoyment than setting performance goals, indicative of a fixed mindset (Rawsthorne & Elliot, 1999; Shim et al., 2013). Intrinsic interest and enjoyment are important motivators that impact attrition. Seymour and Hewitt (1997) found that the top three reasons why women left STEM degree programs are all related to intrinsic interest and enjoyment, which was not the case for men who left the same programs. These motivators are also the second-best predictors of engineering success in college after math ability, more predictive than other common indicators like high school and college GPA or SAT scores (Levin & Wyckoff, 1988).

### *Mindset and Attrition*

Mindset influences attrition through both achievement and motivation. Burkley et al. (2010) found that women who believed their mathematics skills were fixed showed less identification and interest in the subject and less desire to pursue a mathematics-related field; "these results suggest that women with fixed-trait beliefs are more likely to fall prey to the gender gap that exists in mathematics fields" (p. 234). This decrease in domain-specific interest and aspirations is linked to both lower expectancy of success and higher rates of attrition (Seymour & Hewitt, 1997; Wang et al., 2017). This conclusion

aligns with Romero et al.'s (2014) finding that students with growth mindsets in middle school are more likely to take more advanced mathematics courses in their future.

Because no single academic or non-academic cause can explain why female students leave STEM pathways at greater rates than their male peers, exploring several potential factors is necessary (Seymour & Hewitt, 1997). However, the literature suggests that mindset could play a significant role in explaining the local pattern of disproportionate attrition of female students in the high honors pathway.

## Stereotype Threat

Stereotype threat is a social-psychological threat that occurs when students are exposed to negative stereotypes about a group in which they are a member and respond in ways that confirm the stereotype (Steele, 1997; Steele & Aronson, 1995). Activating negative stereotypes, or even leaving them unchecked, catalyzes disruptive psychological processes that undermine academic performance (Croizet et al., 2004; Danaher & Crandall, 2008; Dar-Nimrod & Heine, 2006; Good et al., 2003, 2008; Nguyen & Ryan, 2008; Shapiro & Williams, 2012). This section discusses the history of stereotype threat and its theoretical background, followed by its relationship to achievement, motivation, and attrition, with a particular emphasis on female students in mathematics.

### *History and Theoretical Background*

Stereotype threat as a psychological theory was first introduced in 1995 by the social psychologists Steele and Aronson. While researchers like Benbow and Stanley (1980) maintained that the race and gender achievement gaps were biological inevitabilities, Steele and Aronson (1995) suspected an alternative explanation and conducted four studies with Black and White college students. The first two studies tested

whether the diagnostic nature of a verbal test, which increases risk of confirming negative stereotypes for Black students, would impact performance. Controlling for SAT scores, they found that Black students underperformed in relation to White students only in the diagnostic condition. The third study found that the diagnostic nature of the test significantly increased cognitive activation of stereotypes about Black students, increased concerns about their own ability, increased tendency to avoid racially stereotypic preferences, increased tendency to make advance excuses for their performance, and increased reluctance to have their racial identity linked to their performance. Steele and Aronson (1995) described this apprehension as stereotype threat. The final study tested whether asking for race on a personal questionnaire before a nondiagnostic test was enough to activate stereotype threat. It was.

Four years later, Steele and Aronson (1999) published a nearly identical set of studies on women in mathematics and found similar results, suggesting that stereotype threat might partially explain the achievement and attrition gender gaps in mathematics. From these formative studies, many followed, not only for women in other subjects like physical sciences (Flore & Wicherts, 2015) and even chess (Maass et al., 2008), but also for Black and Latino/a students in all subjects (Nguyen & Ryan, 2008), as well as White men in athletics (Stone et al., 1999), women in athletics (Gentile et al., 2018), older people (Lamont et al., 2015), women in entrepreneurial domains (Gupta & Bhawe, 2007) and even men in tests of social sensitivity (Koenig & Eagly, 2005). The medical consequences of stereotype threat are also well documented (Aronson et al., 2013; Blascovich et al., 2001; Scheepers et al., 2012).

From this literature, a theory of stereotype threat developed. Schmader et al. (2008) consolidated the known body of research into a single integrated model of stereotype threat that focused on three interrelated factors: (a) heightened stress, (b) performance monitoring, and (c) efforts to suppress negative thoughts and emotions. These factors are explained by the psychological and physiological mechanisms of stereotype threat.

**Psychological and Physiological Mechanisms.** Studies show that stereotype threat interferes with working memory and executive function (Inzlicht et al., 2006; Schmader & Johns, 2003) and increases performance-related self-consciousness (Beilock et al., 2006) and stress arousal (Ben-Zeev et al., 2005). Physiologically, individuals under stereotype threat have been shown to experience increased blood pressure and heart rate (Blascovich et al., 2001; Croizet et al., 2004; Murphy et al., 2007) as well as a neuroendocrine stress response (Townsend et al., 2011).

Krendl et al. (2008) also investigated the neural mechanisms of stereotype threat. They used fMRI to measure changes in brain activity for women experiencing stereotype threat during a mathematics test and found elevated activation in the ventral stream of the anterior cingulate cortex, a region of the brain linked to social and emotional processing, two actions that are not necessary for the quantitative task at hand so therefore suggest performance monitoring and efforts to suppress negative thoughts and emotions. In another study, the level of activation in the brain region even predicted performance reductions (Wraga et al., 2007).

**Threatening Environments.** The primary hypothesis of stereotype threat theory is that stereotype threat interferes with performance and predicts that stereotyped

individuals will perform worse in threatening environments than they would in nonthreatening environments (Nguyen & Ryan, 2008). Stereotype threat is situational—what Steele (1997) called the "threat in the air" (p. 614)—and can affect members of any group that is negatively stereotyped. However, only threatening environments will induce detrimental stereotype threat.

Stereotype threat theory suggests three primary conditions that create a threatening environment. First, beyond being a member of a group with a negative stereotype, a student must be aware of the existence of the stereotype (Aronson et al., 1999). This awareness does not have to be conscious or even prompted for individuals to feel the effects of stereotype threat (Nguyen & Ryan, 2008). Second, students must care about doing well at the task (Aronson et al., 1999; Steele, 2010), and finally, the task must be challenging (Nguyen & Ryan, 2008; O'Brien & Crandall, 2003).

### ***Stereotype Threat and Achievement***

According to Devos and Banaji (2003), stereotype threat theory predicts and empirically tests the relationship between negative stereotypes of a group and the group members' behavioral changes, like decreased performance, which has implications for the academic achievement of stereotyped groups, like women in mathematics. The evidence that stereotype threat affects the mathematics performance of female students, and especially high-achieving and highly mathematics-identified female students, is robust (Aronson & Steele, 2005; Inzlicht & Ben-Zeev, 2003; Nguyen & Ryan, 2008; Steele et al., 2002) and the detrimental effects have undermined girls' mathematics performance as early as sixth grade (Good et al., 2008). Nguyen and Ryan (2008) published a meta-analysis of 116 academic papers investigating stereotype threat and

found that, for women, subtle threat-activating cues were the most detrimental, followed by blatant then moderately explicit. Examples of subtle threat-activating cues include emphasizing the diagnosticity of a test or asking for a student's gender before the test (called gender priming). Thus, female students interact with negative stereotypes automatically and/or subconsciously and do not need explicit reminders of their existence to feel their effects.

Additionally, interventions to mitigate stereotype threat for female students in mathematics have been moderately successful (Brown & Pinel, 2003; Danaher & Crandall, 2008; Davies et al., 2002), which suggests a causal relationship. Nguyen and Ryan (2008) found that explicit threat-removal strategies, like educating students about stereotype threat or explicitly stating that a mathematics test is free of gender bias, were more effective for reducing gender-based stereotype threat in mathematics than subtle strategies.

High-achieving or highly mathematics-identified female students also experience stereotype threat in especially challenging courses, like the high honors pathway. Evidence of stereotype threat has been documented in rigorous, high-level university mathematics courses, where female students are objectively high-achieving and highly mathematics-identified (Good et al., 2008), as well as their high school equivalents (Danaher & Crandall, 2008). Aronson et al. (1999) said early on in the stereotype threat literature that its effects are most keenly felt by highly mathematics-identified students. This claim has since been corroborated by meta-analysis (Nguyen & Ryan, 2008).

### ***Stereotype Threat and Motivation***

Stereotypes affect more than just achievement. According to Jouini et al. (2018), stereotypes are associated with higher psychological risk; they impact psychological utility like disappointment and elation and lead to lower self-confidence. This occurred for women in mathematics even where performance is high (Linn & Hyde, 1989). While psychological risk plays a significant role in attrition, how it manifests depends on an individuals' response to threatening environments.

Students often react by either externalizing or internalizing the negative stereotypes, both of which affect their behavior (Owens & Massey, 2011). Students who externalize negative stereotypes worry that their academic performance will reflect negatively on the group in which they are a member and confirm stereotypes for themselves and others (Schmader et al., 2008). Therefore, a portion of the students' cognitive load, instead of being devoted to the task at hand, is anxious (Steele, 1997). Other negative effects include decreased feelings of belonging (Walton & Cohen, 2007) and stress (Blascovich et al., 2001). Students who internalize negative stereotypes also experience negative consequences. They avoid challenges and adopt maladaptive self-protecting strategies (Owens & Massey, 2011; Smith, 2004), which affect both their confidence and decision-making (Jouini et al., 2018).

### ***Stereotype Threat and Attrition***

Attrition, as stated previously, is based upon both achievement and motivation. However, ultimately, the decision to leave the high honors mathematics pathway is just that: a decision. Stereotypes can influence students' performance and confidence, two important factors in risk-assessment and benefit-analysis, however Jouini et al. (2018)

also found that stereotypes can lead individuals to make less ambitious choices, even when controlled for objective ability. They argue that the presence of a negative stereotype about women in mathematics creates different psychological risks for female and male students. This psychological risk affects self-esteem and motivates different protection strategies that affect confidence and decision-making. Essentially, the psychological risk of disappointment is greater for female students than for male students, engendering underconfidence and risk aversion and ultimately causing female students to make less ambitious choices in order to reduce future psychological risk (Jouini et al., 2018). In this study, the high honors pathway represents that more ambitious choice.

Additionally, Jouini et al. (2018) suggested that highly able female students might self-select into challenging math environments less than less able female students, which could explain why the gender gap in mathematics is the greatest in the top echelon of students, rather than the middle. Ellison and Swanson (2018) found a significant participation and performance gap at mathematics competitions, with the highest-achieving girls hailing from a few elite schools. When they analyzed students who fell just short of qualifying for the prestigious second stage exam, they noticed some students, most commonly girls, reacted to this perceived failure by dropping out completely in the following years. This could partially explain why the high honors pathway, where high-achieving students often encounter their first significant setbacks in math, has a pattern of disproportionate attrition of female students while the standard honors pathway does not.

Another potential cause for this difference in attrition rates between the high honors and honors pathways is the nature of the courses. O’Brien and Crandall (2003)

found that threatening environments only detrimentally affected female students' mathematics performance when the tests were difficult; on easy tests, a threatening environment actually improved scores. The high honors pathway is fast-paced and rigorous. Therefore, its courses create more threatening environments for more female students, potentially increasing the role of stereotype threat in attrition rates.

Notably, stereotype threat is not the only way negative stereotypes contribute to the achievement and attrition gaps. Steele and Aronson (2004) insisted stereotype threat is just one factor and were concerned that people would mischaracterize stereotype threat research as a "silver-bullet cure for the [achievement] gap" (p. 47). However, they did believe that the overwhelming majority of studies on stereotype threat adequately depict stereotype threat as just one of many causes. Stereotype threat does not explain the achievement or attrition gaps in the general population, but rather is a principal factor that might explain the gaps in a subsample where groups are equal on other causes (Massey et al., 2003). For this study, the high honors mathematics pathway at a single large public high school is that subsample.

**Fear of Failure**

People inherently desire to be seen as competent, and students are no exception (De Castella et al., 2013). Therefore, for many students, failing is an anxiety-inducing, fearful, unfavorable experience that impacts their motivation and overall performance (Choi, 2020). Notably, failure does not necessarily mean failing a class; failure is defined by the individual based on their own standards for success. Fear of this failure is a psychological mechanism behind an individual's emotional and motivational tendency to avoid a failing situation in achievement domains and evaluative contexts (Atkinson,

1957; Covington, 2000; Elliot & Thrash, 2004). The disproportionate attrition rate of female students could result from this avoidance. This section discusses the history of fear of failure research and its theoretical basis, followed by connections to achievement, motivation, and attrition, emphasizing female students in mathematics where possible.

***History and Theoretical Background***

The motivation to avoid failure and approach success does not have a singular conceptual origin. In fact, its history in the achievement and motivation literature is long, potentially dating back to the ancient Greek philosophers Democritus (460–370 B.C.) and Aristippus (435–356 B.C.), who described the avoidance of pain and pursuit of pleasure as drives for all human behavior (Elliot & Covington, 2001). Since then, researchers have described the motives to avoid failure and approach success as implicit needs that drive behavior (Atkinson, 1957; McClelland, 1965), attributions (Weiner, 1985), temperaments (Elliot & Thrash, 2004), neuropsychological systems (Carver & White, 1994), and orientations linked with performance goals (Covington, 1992; Elliot & Dweck, 1988).

Despite the varied descriptions, a theme emerges. Failure-fearing students are characterized by their fear and self-doubt while success-oriented students are characterized by their resilience and enthusiasm for learning (De Castella et al., 2013). Early on, these characterizations were seen as two poles of a bipolar spectrum; students only varied in their relative levels of hopes and fears (Feather, 1961; Moulton, 1965). However, success orientation and fear of failure can interact in ways that produce different behavioral responses that create qualitatively different student profiles (Covington, 1992).

**The Quadripolar Model.** Covington's (1992) quadripolar model is one such representation of the different student profiles that emerge when considering fear of failure and orientation for success together. This model (Figure 2.1) groups students into four categories: (a) failure acceptors (students with both low success orientation and low fear of failure), (b) self-protectors (students with low success orientation and high fear of failure), (c) optimists (students with high success orientation and low fear of failure), and finally (d) overstrivers (students with both high success orientation and high fear of failure).


**Figure 2.1:** The Quadripolar Model from De Castella et al. (2013)

Several studies corroborated the quadripolar model (Covington & Omelich, 1988; De Castella et al., 2013; Martin et al., 2001) and incorporated it into self-worth theory as a method of predicting behavior (Covington, 1992; De Castella et al., 2013).

**Self-worth Theory.** Self-worth theory is an integrated theory of motivation derived from two related views. First, achievement is the result of an emotional conflict

between striving for success and avoiding failure, an idea first developed by Atkinson (1957), who called this view drive theory. Second, goals give meaning, direction, and purpose to all behavior, an idea first developed by Elliot and Dweck (1988), who called this view goal theory. Self-worth theory assumes that the ultimate goal of any person is a sense of self-acceptance and belonging in society, which, in turn, motivates a fear of failure and an orientation to approach success (Covington, 2000; De Castella et al., 2013). Academically, worth is largely measured by achievement; therefore, perceptions of incompetence can trigger shame and/or humiliation. According to self-worth theory, students will protect themselves and their self-worth from these feelings using predictable defensive strategies derived from their fear of failure (Fried-Buchalter, 1992; Thompson et al., 1998).

Three categories of self-protective mechanisms include (a) self-worth protection or helplessness, (b) self-handicapping, and (c) defensive pessimism (Thompson, 1993). Covington (2000) elaborated on each category: students who adopt helplessness will withhold effort when facing a risk of failure, hoping that if they fail, lack of effort is the culprit instead of incompetency. Students who self-handicap will create a barrier to their own success, providing a preemptive excuse for potential failure. Handicapping strategies include procrastination or unrealistically high achievement expectations. Defensive pessimism is characterized by holding unrealistically low expectations for oneself to stifle potentially overwhelming anxiety that could occur when attempting a task.

### *Fear of Failure and Achievement*

The fear of failure in academic contexts is linked to achievement. Fear of failure negatively correlates to academic success (Herman, 1990) and the higher a student’s fear

of failure, the lower their grades (Schmalt, 1999, 2005). Additionally, fear of failure is a predictor of general and mathematics-specific academic performance over various measures of intelligence (Steinmayr & Spinath, 2009). Lerch et al. (2018) also demonstrated that fear of failure impacts learning. Students with high fear of failure showed slower information accumulation and lower learning rates, even under conditions of primarily positive feedback.

The implications for equity are significant, as female students experience higher levels of fear of failure than male students (McGregor & Elliot, 2005). Additionally, studies have shown that fear of failure is a better predictor of a female student's mathematics grade than general cognitive ability while it does not predict achievement for their male peers (Steinmayr & Spinath, 2008; Wach et al., 2015). Both Steinmayr and Spinath (2008) and Wach et al. (2015) concluded that, for female students only, fear of failure affected performance in quantitative courses, such as mathematics, but not performance in verbal courses.

Using the quadripolar model, the two groups with high fear of failure are the self-protectors and overstrivers; self-protectors have a high fear of failure and a low success orientation, while overstrivers have a high fear of failure and a high success orientation. In practice, they can be identified by the protective strategies they adopt. Defensive pessimism is unique to both types of failure-fearing students, while self-protectors also adopt self-handicapping. Neither group tends to adopt helplessness. In this study, participants are high-achieving female students in a rigorous high honors mathematics pathway. Because other course options have equivalent GPA ramifications, students who self-select to start in this pathway most likely have a high success orientation. Using this

logic, most students in this study are overstrivers. For many overstrivers, the high fear of failure and high orientation of success actually motivate their achievement; they are more likely to respond to their fears by increasing effort rather than adopting strategies that could undermine their performance (De Castella et al., 2013). However, this determination often comes with a cost, especially when the task is challenging, and can negatively affect motivation.

### *Fear of Failure and Motivation*

The cost of a fear of failure can be steep. Overstrivers might often achieve success; however, in especially difficult tasks, they are at higher risk for emotional fatigue and burnout (De Castella et al., 2013). These students subsequently experience high anxiety and unstable self-esteem, and when presented with challenges or setbacks, they often lack resiliency (Covington, 1992; Martin et al., 2001; Martin & Marsh, 2003). In a challenging academic pathway, resiliency in the face of challenges is vital for continued success. The emotional barriers induced by a fear of failure exacerbate the already existing divide between female and male students' psychological experiences where teenage girls are significantly more likely to report unhealthy behaviors due to stress than their male peers in every category that the American Psychological Association (2014) investigated.

Fear of failure is also a positive feedback loop. When students fear failure and develop maladaptive self-protection strategies, their performance can suffer, thereby increasing their fear of failure (De Castella et al., 2013). Covington (1992) argued that increasing pressure on students to try harder during risk of failure will only exacerbate the problem. This finding has important implications for attrition.

***Fear of Failure and Attrition***

For students who have a high fear of failure, opportunities for academic achievement are not simply opportunities to learn, grow, or compete against peers; they are inherently threatening experiences rife with judgment that put their entire sense of worth on the line (McGregor & Elliot, 2005). When less than perfect grades are misinterpreted as failure, they present an intolerable threat to individuals with identities that rely on high grades (Seymour & Hunter, 2019). This is especially significant for female students in STEM who are more likely to have extrinsic measures of identity and worth than their male peers (Seymour & Hunter, 2019). Additionally, overstrivers are more likely to adopt defensive pessimism than any of the other self-protection strategies (De Castella et al., 2013). This is especially true for female overstrivers (Thompson & Le Fevre, 1999). Recall that defensive pessimism is a self-protection strategy that allows students to alter the meaning of failure by holding unrealistically low expectations for themselves (Covington, 2000). This strategy "protects" them from the possibility of overwhelming, debilitating anxiety caused by challenging events (Cantor & Norem, 1989, p. 93). Defensive pessimism is best summarized in a student interview from Martin et al. (2003) in which a student explained:

> I think if I border slightly on the pessimistic, then if I do better than I expected then it's a pleasant surprise, and if I do worse than expected then it's less of a fall. You just try to minimize those falls. (p. 621)

This reasoning could explain why some female students decide that the risk of staying in the high honors pathway is just too high.

In the short term, defensive pessimism might protect students' self-esteem, but longitudinal studies have associated this attitude with lower GPAs, higher life stress and dissatisfaction, and increased psychological problems (Martin et al., 2001; Martin et al., 2003). Thus, while this self-protection strategy might seem minor or temporary, it risks establishing a pattern that can have significant long-term consequences.

## Other Possible Causes

Mindset, stereotype threat, and fear of failure are three factors researchers use to explain the achievement, motivation, and attrition gaps between female and male students in mathematics. However the literature is rife with other hypothesized causes documented in various contexts, such as mathematical anxiety, peer effects, and implicit bias.

### *Mathematical Anxiety*

Mathematical anxiety is a feeling of tension and fear that accompanies mathematics-related contexts (Richardson & Suinn, 1972) and its debilitating effects on the development of mathematics skills is well documented according to several meta-analyses (Ma, 1999; Wang et al., 2014; Zienteck et al., 2010). Caused by both environmental and genetic factors and partially linked to general anxiety (Wang et al., 2014), mathematical anxiety impacts an individual's cognitive capacity and affects the perception of mathematics-related environments, so it is doubly hazardous (Ho et al., 2000). Mathematical anxiety, therefore, is associated with lower achievement in mathematics, avoidance of situations that involve the subject, and decreased engagement in STEM careers (Hembree, 1990). These performance and motivational effects can cause high levels of anticipatory anxiety, leading students to avoid mathematics as much as possible (Lyons & Beilock, 2012; Maloney & Beilock, 2012). Given that female

students report higher levels of mathematical anxiety than their male peers (Else-Quest et al., 2010; Goetz et al., 2013; Hill et al., 2016), it is one potential cause of the attrition of female students in the high honors pathway.

### *Peer Effects*

Peer relationships and social networks are instrumental to students' development of positive academic identities, especially in high school (Horvat & Lewis, 2003, Ryan, 2001). However, studies suggest that women's academic choices may be more affected by peers and role models than men's (Bagès et al., 2016; Fischer, 2017; Lim & Meer, 2017). For example, high mathematics-identifying female students in minority settings performed worse than when they were in all-female settings (Inzlicht & Ben-Zeev, 2003). Cohen and Swim (1995) even demonstrated that women in minority settings, also known as token women, were more likely than nontoken women to expect being stereotyped against and to want to change groups. Token and nontoken men did not report this. In fact, exposure to high-achieving female peers in mathematics courses increases the likelihood that women choose a STEM track during high school (Mouganie & Wang, 2020), implying that attrition of female students from the high honors mathematics pathway is a positive feedback loop: the more high-achieving female students who leave, the more will follow.

### *Implicit Bias*

Finally, teachers' implicit bias against female students in mathematics could generate the chilly environment that Seymour and Hewitt (1997) described in academic settings. Implicit biases are discriminatory attitudes and behaviors that individuals are unaware of and therefore operate under the surface of consciousness (Gawronski &

Bodenhausen, 2006). Studies have shown that teachers' perceptions and actions have significant consequences for their students' academic achievement, self-perception, and future trajectories (Benner & Graham, 2011; Farkas, 2003). While some teachers may argue that their decisions and actions are based on an accumulation of daily experiences with their students, experimental evidence shows that this is not the full picture. For example, Copur-Gencturk et al. (2019) found that, while teachers did not display any detectable bias when assessing the correctness of student answers, their estimations of the students' mathematical ability favored male students. Even though relatively few teachers explicitly express the belief that girls have lower innate mathematical ability than boys (Copur-Gencturk et al., 2020), this is not necessarily the reality. This research has important implications for attrition because teachers recommend students for the high honors pathway and subsequent courses. While most use achievement data, perception of mathematical ability can also influence recommendations. This conclusion is corroborated by research showing that implicit biases against female students in mathematics predicted tracking decisions (Nürnberger et al., 2016).

**Summary**

Mindset, stereotype threat, and fear of failure, as well as mathematical anxiety, peer effects, and implicit bias may all affect the attrition of female students in the high honors mathematics pathway. Because Seymour and Hewitt (1997) asserted that achievement and motivation both influence attrition, this chapter connected the background literature of each potential cause not only to attrition, but also to achievement and motivation. The history and theoretical underpinnings of the three main hypothesized

causes (mindset, stereotype threat, and fear of failure) provide important context for understanding the reasoning behind the study.

The purpose of this study is to examine which of these documented causes, if any, contribute to the disproportionate attrition rates of female students in the high honors pathway. Many researchers recognize that individual causes, like mindset, stereotype threat, or fear of failure, are not adequate to sufficiently explain the gender gaps in achievement, motivation, and attrition (Dweck, 2007; Steele & Aronson, 2004). Therefore, a targeted analysis of the environment that engenders this pattern is critical. This analysis has ramifications not only for the attrition gap in STEM degrees and STEM careers, but also for the overall gender achievement gap that is still present among top achieving students (McGraw et al., 2006; Reardon et al., 2019). For this reason, and others aforementioned, scholars like Dweck (2006) and Jouini et al. (2018) believe that the difference in math emerges at the top of the ability distribution and that policy interventions "should not only aim to get *more* girls to participate, but they should especially target the most able girls" (Jouini et al., 2018, p. 42). These findings suggest that the attrition of female students in the high honors pathway is a positive feedback loop. In order to break this cycle, it is critical to understand and target the factors that push female students to leave the pathway.

# CHAPTER 3

# METHODOLOGY

Women are underrepresented in STEM, and the more mathematics a field requires, the greater the disparity (Beede et al., 2011; de Brey et al. 2019; Martinez & Christnacht, 2021). Because mathematics is the gatekeeper to STEM degrees (Cobb & Hodge, 2011; Stinson, 2004), addressing the disproportionate attrition pattern in the high honors mathematics pathway is necessary for providing equal educational, career, and economic opportunities for female students in this community. However, before targeting the disparity with interventions, understanding the phenomenon is imperative. Therefore, the purpose of this study is to investigate when and why fewer female students participate in the high honors mathematics pathway to gain insight for creating an effective and sustainable intervention.

## Research Questions and Hypothesized Answers

This purpose informs the study's two research questions:

- RQ1: In a large, public high school in an affluent, highly-educated city, when do female students leave the high honors mathematics pathway?
- RQ2: Why do female students leave the high honors mathematics pathway?

Research on this phenomenon at the college level shows a chronological pattern where the rate of attrition was not constant throughout a program. Seymour and Hewitt

(1997) found that most undergraduate female students leave quantitative majors, like mathematics, after their first year. More leave after their second year but at a lower rate than the first year, and hardly any leave after. A similar pattern was expected to be found in this study.

Based on discussions with students, colleagues, and the academic literature on attrition, three main causes seemed most likely: mindset, stereotype threat, and the fear of failure. These three provide the foundation of the study's theoretical framework. Regarding mindset, studies have shown that female students are more likely to have a fixed mindset and therefore less likely to pursue mathematics as they encounter challenges (Boaler, 2016; Boaler & Sengupta-Irving, 2006; Dweck, 2006). This pattern is especially true for high-performing female students (Boaler & Sengupta-Irving, 2006; Licht & Dweck, 1984). Stereotype threat is also well documented in university mathematics courses (Krendl et al, 2008; Spencer et al., 1999), where women report feeling a chilly climate where their abilities and professional ambitions are questioned, and that they have to prove themselves constantly (Seymour & Hewitt, 1997). Stereotype threat likely affects the high honors pathway more than the honors pathway because the phenomenon is debilitating at the frontier of a person's current ability (O'Brien & Crandall, 2003). The high honors pathway is more challenging and rigorous than the honors pathway, insuring that a higher proportion of female students are operating at the border of their current ability therefore feeling the detrimental effects of stereotype threat more keenly. Finally, the fear of failure seems significant. When students place a portion of their self-worth in academics and define success as doing better than their peers, they may be forced to avoid failure (Covington, 2000) and develop debilitating strategies that

can negatively impact their achievement, confidence, and decision-making long term (Jouini et al., 2018, Thompson, 1994). This dynamic could likely affect whether a female student decides to stay in the pathway year-to-year.

## Research Design

The research questions, the theoretical framework, and the hypothesized answers inform the explanatory sequential mixed methods action research approach of this study.

### *Action Research as the Chosen Methodology*

Action research is an investigation by an educator in their own setting, wherein students are not test subjects but participants (Efron & Ravid, 2013). Students' contributions help shaped the direction of the study so to better identify common themes within their experiences. The insider relationship provided the opportunity to build rapport, increase student buy-in, and notice patterns that might not have been immediately obvious to an outside researcher.

Herr and Anderson (2015) expanded this definition by adding that action research is "a reflective process, but is different from isolated, spontaneous reflection in that it is deliberately and systematically undertaken" (p. 4). This chapter details the data collection and analysis that differentiates this study from isolated spontaneous reflection: each artifact was intentionally and systematically collected and analyzed with techniques appropriate to the category of data. This process contributed to the reliability and validity of this study (Merriam & Tisdell, 2016).

One of the greatest strengths of action research is its ability to address the immediate needs of people in specific settings and the direct utility of the knowledge generated (Herr & Anderson, 2015). This is why action research was chosen – with the

hope that the results and findings from this study can be used to make lasting and effective change within the community studied. Efron and Ravid (2013) expounded upon this understanding: "[teachers] recognize that for strategies to be uniformly applicable, all students must be viewed as essentially similar. However, the uniqueness of each student and the particular historical, social, economic, and cultural context of each setting belie this viewpoint" (p. 3). Action research as the chosen methodology provides the scaffold for the rest of the research design.

***Mixed Methods, Explanatory Sequential Design***

This study is mixed methods because each research question requires a different approach, drawing on the strength of each method to best answer each one (Efron & Ravid, 2013). Collecting quantitative enrollment data first established the pattern of attrition. Quantitative achievement and survey data along with qualitative interview data could then explain the pattern, hence the explanatory sequential design (Creswell & Plano Clark, 2018) illustrated in Figure 3.1.

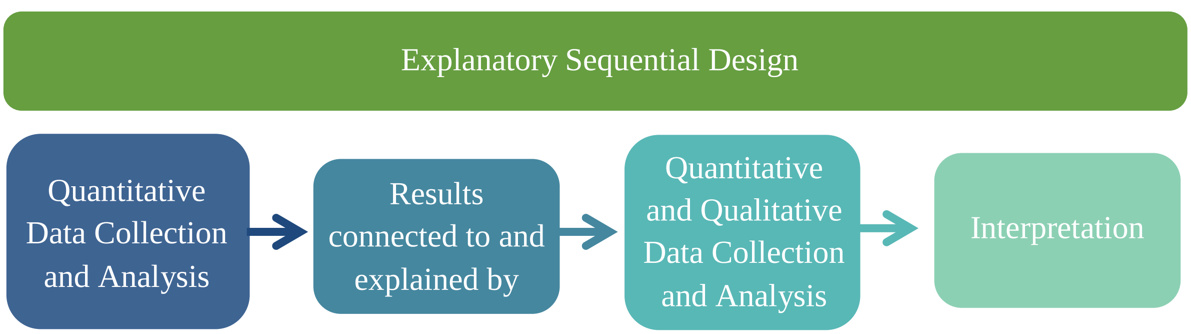


**Figure 3.1:** Explanatory Sequential Design

RQ1 was intentionally first and warranted a quantitative descriptive research approach. Descriptive research was most appropriate because its purpose is to quantify

existing settings, groups, or phenomena and compare multiple variables (Efron & Ravid, 2013). Chronological patterns of when female students leave a high honors mathematics pathway stem from course enrollment numbers, a quantitative dataset.

It was hypothesized that the attrition pattern in this setting would match the documented timeline of attrition of female undergraduates in STEM majors: the greatest rate of attrition being after their first year, second greatest after their second year, and then a small change, if at all, during their final two years (Seymour & Hewitt, 1997). The theoretical framework of attribution theory and implicit theories of intelligence, stereotype threat, and self-worth theory of motivation overlap in their framing of students encountering challenging material. The first and second courses in the high honors pathway are known to be the most challenging when compared to students' previous middle school mathematics courses. Therefore, it is reasonable to assume that if a female student feels successful in these two most challenging courses then she will think the last two within her capabilities.

Understanding and describing the quantitative chronological attrition patterns informed both the quantitative investigation of RQ2 and the qualitative, phenomenological approach. Because some courses in the pathway have higher rates of attrition than others, focusing the qualitative data collection and analysis on students who left during this time period promised more precise approximation of the overall causes of the disproportionate attrition.

A qualitative, phenomenological approach was best suited to answering RQ2 because of the specific, knowable essence to the shared experience of these female students that this study aimed to understand and describe (Patton, 2015). All three facets

of the theoretical framework—attribution theory and implicit theories of intelligence, stereotype threat, and self-worth theory of motivation—focus on the affective features of the students' worldview, which can give rise to intense discussions of their perceived failures and shortcomings, hence the phenomenological approach (Merriam & Tisdell, 2016) to RQ2, which delves into the emotional reasons why these female students leave the pathway. Qualitative data, therefore, were essential to understand and describe the complex story of the female students' collective experience in the high honors pathway.

### *Context and Setting of the Study*

This study took place in a large, public high school in an affluent, highly-educated city and focused on the female students who left the high honors mathematics pathway.

**Description of the School.** Crescent High School (a pseudonym) is a large, public high school with approximately 2,200 students, grades 9–12. It is one of four high schools in a city of approximately 100,000 people and one of eight high schools in the local school district. According to district documents, 50% of the students in the district are open enrollment, meaning they do not live in the local boundaries that directly feed into whichever high school they attend. As such, each high school in the district promotes themselves as filling a specific niche within the community. The niche Crescent High School fills is obvious; the school's website is littered with phrases like "rich academic pathways," "rigorous academic program," and "our curriculum is designed to challenge." This reputation for strong academics is reflected in the school's published profile, a two-page fact sheet that highlights the academic achievements of its student body: over 80% of seniors take an AP or IB course, about 15% are IB diploma candidates, 9.6% of the 2019 graduating class were National Merit Scholars, and 3.6% were Finalists. The mean

SAT and ACT scores well outpace state and national averages. Crescent High School, with its reputation for high academic performance, attracts students and families with that same priority, creating a highly competitive, achievement-motivated school culture, the hazards of which are often discussed among students, teachers, and administrators.

The school's affluence is notable, especially because family income is linked with academic performance (Reardon, 2013). According to Zillow, the median home price within the local community in 2022 is $1,012,326, a 21.4% increase from the previous year. This affluence contributes to the increasing proportion of open enrollment students at Crescent High School, as a single-family home within the local feeder community becomes more financially unrealistic. On the other side of the spectrum, approximately 11% of students at Crescent High School receive free or reduced-price lunch, the lowest proportion of all the high schools in the district.

Crescent High School is also predominantly White; 72% of the students are White, 11% are Asian, 10% are Hispanic, 7% are multi-ethnic, and 1% are Black. Additionally, 52% of the student body is female and 48% are male. Official records provide no statistics for non-binary students, yet non-binary students attend the school.

**Description of the High Honors Mathematics Pathway.** The high honors mathematics pathway is a four-year pathway that leads students from intermediate algebra through Calculus 3 (Figure 3.2). Students complete Algebra 1 and Geometry before entering the pathway at Pre-IB Algebra 2/3, the first course.

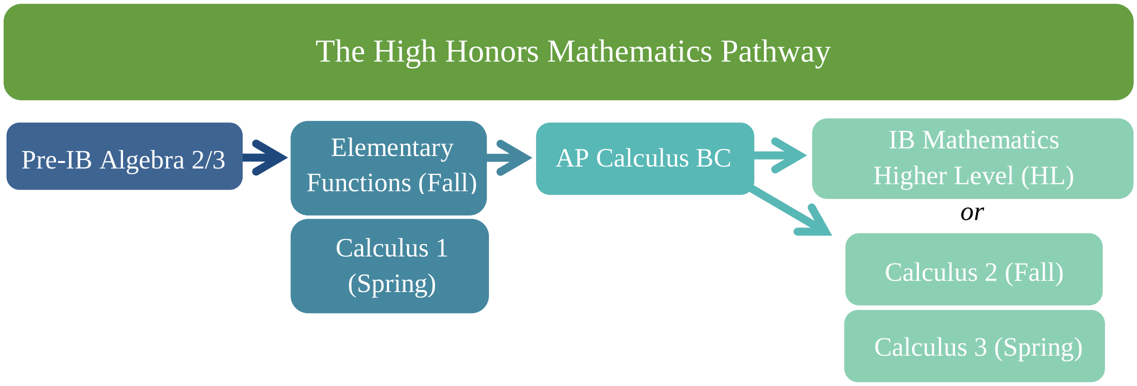


**Figure 3.2** *The High Honors Mathematics Pathway at Crescent High School*

AP Calculus BC is required before Calculus 2 and 3 because the latter two courses are offered in partnership with a local public university that only gives credit to students in Calculus 2 and 3 if they already have college credit for Calculus 1. However because the Calculus 1 course does not share the same university partnership (due to an administrative road block), students must acquire credit for Calculus 1 through the AP Calculus BC exam.

While more than half of the students (61.6%) enter the high honors mathematics pathway as ninth-grade students, 32.8% are in tenth grade and 5.6% are middle school students. The tenth-grade students exit the pathway after the third step, AP Calculus BC, when they graduate from high school.

## Participants

The participant sample and its characteristics differed for each research question, as did the methodology and data sources.

### *Sample and Sampling Type to Answer RQ1*

Two data sets were used to answer RQ1: (a) all students in the high honors pathway at the school between 2012 and 2022, and (b) the students who took the first course of the high honors pathway in the fall of 2018, referred to as the 2018 Cohort.

Sampling for the first was probability, population sampling because the dataset represented the entire population of students in the high honors pathway over 10 years (Creswell & Plano Clark, 2018). This longitudinal enrollment dataset did not include demographic information about the students in the sample; therefore, it was impossible to examine any gender-specific patterns of attrition. The second set was needed to address this gap. The 2018 Cohort was chosen because it was the most recent cohort through the pathway with available and complete enrollment, demographic, and achievement data. This sample was therefore nonprobability, purposeful, convenience sampling (Creswell & Plano Clark, 2018).

***Sample and Sampling Type to Answer RQ2***

Three samples were used to answer RQ2: (a) the 2018 Cohort, owing to the same rationale as for RQ1, (b) survey respondents who left the high honors pathway during or immediately after the 2021 fall semester, and (c) the female interview participants selected from the survey respondent sample. The latter two samples were intentionally chosen from a more recent cohort to reduce the time gap between when the student decided to leave the high honors pathway and when data was collected, hoping to mitigate the influence of time on participants' perceptions of past events, thus bolstering validity (Merriam & Tisdell, 2016). Both samples resulted from nonprobability, purposeful, convenience sampling (Creswell & Plano Clark, 2018). In addition, the interview sample reflected maximum variation sampling because participants from the survey sample were chosen to represent the greatest variation of experiences. Patton (2015) recommended this approach: "any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central

shared dimensions of a setting or phenomenon” (p. 283). Using sample sizes as large as those used to answer RQ1 was impossible so maximum variation minimized the impact of a small sample size.

**Data Collection Methods**

Like samples and sampling types, the data collection instruments, tools, and strategies differed for each research question, chosen specifically to provide the most reliable and valid answers (Table 3.1).

**Table 3.1**
*Data collection instruments, tools, and strategies used to address each research question*

| Research Question | RQ1: When? | RQ2: Why? |
|---|---|---|
| Instruments, Tools, Strategies | Course enrollment data for the high honors pathway from 2012-2022 | Achievement data from the 2018 Cohort |
| | Enrollment and demographic data from the 2018 Cohort | Diagnostic exam data from the stereotype threat control and experimental groups |
| | | Pathway exit survey data for students leaving the pathway Fall 2021 (including the Mindset Quiz from Dweck (2006) |
| | | Four interviews with select female students who left the pathway in fall 2021. |

***Data Collection Instruments, Tools, and Strategies to Answer RQ1***

Two datasets were necessary to answer RQ1. The first was enrollment numbers for every mathematics class offered at Crescent High School from 2012 to 2022, provided by a school administrator and categorized by the specific mathematics course

and the date the numbers were collected. The dataset was then reduced to only the courses in the high honors pathway and only for September and January, the two months present for all years that represent enrollment at the beginning of each semester. Analysis of this data sought the overall pattern of attrition in the high honors pathway for all students in the last 10 years.

Enrollment numbers from the 2018 Cohort, provided by the teacher who taught the first course of the pathway in 2018–2019 and who also taught the last courses in the pathway for these same students in 2021–2022, were used to investigate the disproportionate attrition of female students. This data was categorized by gender, race, grade level, school where the prerequisite course was taken, diagnostic scores, and grades in the first semester of the pathway. Together, both datasets were necessary for understanding the quantitative pattern of attrition at Crescent.

### *Data Collection Instruments, Tools, and Strategies to answer RQ2*

First, to examine the impact of achievement on why female students leave the high honors math pathway at higher rates than their male peers, quantitative achievement data was collected from the 2018 Cohort, including the score each student earned on the diagnostic test at the beginning of the pathway in August 2018 and the percentage grade they earned in the first semester of the first course of the pathway for the fall of the same year. The diagnostic test is a 75-question instrument that covers content from intermediate algebra and is designed to assess algebraic background knowledge; it is essentially a pretest for the first course in the high honors pathway. Students have 50 minutes to complete this test, which is not supposed to be enough time to finish, and are not allowed to use a calculator.

Investigating the psychological factors that contributed to the pattern of attrition required several instruments, tools, and strategies, typical of mixed methods research. The pathway exit survey (Appendix A) collected information from students who leave the high honors pathway; it used open-ended and Likert-scale questions prompting respondents to rank the importance of different factors in their decision-making process. It also included the mindset quiz (Appendix B), adopted from Dweck (2006), which, along with the corresponding scoring rubric, gathered quantitative data on students' mindsets along a spectrum from fixed mindset to growth mindset.

The final quantitative strategy was an experiment testing the effects of stereotype threat on students' diagnostic scores in the first course of the pathway in August 2021. The research design followed previous studies from Aronson and Steele (1999) and Nguyen and Ryan (2008). Two sections of the course received the standard instructions for the exam, which emphasized its diagnosticity, as the control. The other two sections received instructions shown to mitigate stereotype threat for female students on difficult mathematics exams (Nguyen & Ryan, 2008): students were told that while some standardized mathematics tests revealed a bias toward male students, this one did not.

The heart of the data collection for this study used open-ended protocols, namely semi-structured transcribed interviews with female students who decided to leave the high honors mathematics pathway during or immediately after the 2021 fall semester. Interviews are the keystone of this study because phenomenology explores "people's conscious experience of their life-world" (Merriam & Tisdell, 2016, p. 26). Without their own words, it is impossible to truly understand why fewer female students choose to participate in the high honors mathematics pathway.

In keeping with maximum variation sampling, participants from varied perspectives and situations were selected. Female students were interviewed until information saturation was reached, ensuring the data were reliable and valid in describing the holistic shared experience of being a female student in the high honors pathway (Merriam & Tisdell, 2016). Saturation was determined when the final interview did not introduce any new open codes or themes. In the end, four female students were interviewed and the semi-structured protocol was changed during later interviews to focus on the emerging themes from earlier interviews. Such adaptation is a critical aspect of qualitative data collection and analysis that produces more reliable and valid findings (Merriam & Tisdell, 2016). The final adapted semi-structured interview protocol is in Appendix C.

Particular attention was paid to the ethics of the semi-structured interviews. Exit survey respondents were asked in person whether they were interested in being interviewed about their decision-making process and told who would interview them. They were encouraged to take time to think about their answer and give their consent to be interviewed and recorded after consideration. Informed consent forms were collected at the beginning of the interview. Before recording, participants were told the purpose of the study and that in all cases their anonymity was paramount; their names would not be used either in the study or in discussion of the study and all identifying information, including the recording and transcription of the interview, was to be kept locally on a private computer. All four interviews took place during or after the school day in an empty classroom; participants were given the option of either an open or closed door. At the end of the interview, participants were reminded of the confidentiality of the

interview and told how they could see the results if they were interested. They were also instructed to reach out if they wanted to add any new thoughts, comments, or ideas.

## Data Analysis Methods

Methods for analyzing the data depended on the type of data and had an essential role in promoting the reliability and validity of the results and findings.

### *Data Analysis Methods to Answer RQ1*

All the data collected to answer RQ1 was quantitative. To summarize the pattern of attrition in the first two courses of the high honors pathway, the longitudinal enrollment numbers from 2012 to 2022 were aggregated; all students enrolled in the first course of the pathway in September of each year together were added together to find the total number of students who were ever in the high honors pathway over the last 10 years. This method was repeated for the first course in January and the second course for both months. This population data facilitated accurate and reliable calculation of attrition, measured as a change in percent. Attrition was calculated from one count to the next sequentially as well as from the original first count. To examine the pattern of disproportionate attrition of female students in the high honors pathway specifically, enrollment and gender data from the 2018 Cohort was used. In the 2018–2019 school year, these students enrolled in the first course of the pathway. All eighth- or ninth-grade students from this course who stayed in the high honors pathway are enrolled in either of the last two courses four years later during the 2021–2022 school year. Because the original tenth-grade students had already graduated, this dataset could not reveal attrition directly, but rather the change in proportion by gender for each of the two courses. The

analysis of both of these datasets established the reality of the disparity and the relative rate of attrition in the first two courses.

### *Data Analysis Methods to Answer RQ2*

There were many data collection instruments, tools, and strategies used to answer RQ2, each with its own method of analysis. The first factor investigated was achievement, using diagnostic scores and first semester percentage grades of the 2018 Cohort from the 2018 fall semester when they entered the program. For each of these markers, the data was divided into groups by gender and the arithmetic mean (*M*) and standard deviation (*SD*) was calculated for each group. A two-tailed heteroscedastic *t*-test was used to compare the mean scores of the male and female students, an analysis done separately for the diagnostic scores and the first semester percentage grades. The *t*-value, degrees of freedom, and *p*-value are reported in the analysis and the determination of statistical significance was *p < .05, **p < .01, and ***p < .001, the standard thresholds for statistical significance in educational research. The exact same method of analysis was used to compare mean mindset quiz scores for male and female survey respondents.

To analyze the data from the experiment on stereotype threat, mean diagnostic scores and standard deviations for the control and experimental groups were calculated for both gender groups within the two conditions. Once again a two-tailed heteroscedastic *t*-test was used to compare the mean scores between the control and experimental group, between the male students of each group, and between the female students of each group. The *t*-value, degrees of freedom, and the *p*-value are reported for each test and the determination of statistical significance was the same as for other *t*-tests in this study.

A key facet of explanatory sequential design is that the qualitative data collection and analysis connects to and explains the quantitative patterns that emerge (Creswell & Plano Clark, 2018). Therefore, qualitative analysis derived from interviews with female students who left one of the first two courses of the high honors pathway. The transcripts were coded by theme simultaneously with the qualitative data collection, engaging in phenomenological reduction (Merriam & Tisdell, 2016). Coding took place both electronically and physically. First, the recorded interviews were transcribed into a word document and key phrases were highlighted electronically. From there, these phrases were copied and pasted into a new document, printed, and individually cut out. As more interviews took place, more cut-out key phrases were added to the collection. The first attempt at data analysis was deductive, in which the cut-out key phrases from the interviews were physically grouped together on a table according to the three hypothesized causes of attrition: mindset, stereotype threat, and a fear of failure. The goal was to increase reliability through multiple theories triangulation (Merriam & Tisdell, 2016). However, because many phrases could reasonably indicate more than one of these causes, analysis became inductive. Phrases were first arranged into thematic groups then further subdivided into more nuanced open codes by physically rearranging the cut-out key phrases to better visualize the connections. From this analysis, four primary themes emerged. These themes, along with their open codes, were connected to the background literature, marking each open code as an indicator of one or more of the hypothesized causes. By the fourth interview, saturation was reached and no new themes or open codes were added to the analysis.

### ***Reliability and Validity***

Ensuring reliability and validity in analysis is salient and many strategies were used to increase both. Chapter 1 includes a section on researcher positionality that incorporated critical self-reflection on potential biases. Once the quantitative data was collected, initial data and insights were shared with the other math teacher in the high honors pathway who has taught these courses for 15 years. Conversations with her provided important feedback and increased internal validity through investigator triangulation (Merriam & Tisdell, 2016). Once the qualitative data was collected, interview participants were asked to assess the accuracy of the initial themes. Such member checks are the single most important way of establishing reliability and validity and reducing bias (Maxwell, 2013). Finally, this chapter thoroughly explained the study's methodology, as the next chapter thoroughly explains the results and findings.

# CHAPTER 4

# RESULTS AND FINDINGS

The purpose of this mixed methods action research study was to document and analyze when and why female students were leaving a high honors high school mathematics pathway at rates greater than the male students. At its core, this study used a phenomenological approach, seeking to better understand this pattern to inform more effective and sustainable interventions, and aimed to answer two research questions:

- RQ1: In a large, public high school in an affluent, highly-educated city, when do female students leave the high honors mathematics pathway?
- RQ2: Why do female students leave the high honors mathematics pathway?

This study is significant, addressing a phenomenon well documented in higher education (Seymour & Hewitt, 1997) but under-researched at the secondary level. This gap in scholarship hinders schools' ability to design effective and sustainable interventions. Therefore, this study sought to understand the pattern and its causes more deeply.

The high honors pathway consists of: (1) Pre-IB Algebra 2/3, (2) Elementary Functions/Calculus 1, (3) AP Calculus BC, and (4) either Calculus 2/3 or IB Math HL. This chapter will describe each course using its order in the sequence rather than its name.

## Description of the Sample

Different types of data were essential to adequately investigate the two research questions. To answer RQ1, quantitative data on both longitudinal enrollment patterns in the high honors pathway over the course of the last 10 years and more recent data on the current senior cohort were used. These students, dubbed the 2018 Cohort, started the pathway in the 2018–2019 school year and either successfully completed the pathway or exited. Along with their enrollment history, demographic and achievement data was collected. Tables 4.1 and 4.2 summarize these two samples.

**Table 4.1**

*Demographics at Crescent High School, 2018–2019*

| *n* = 2140 | % | | % |
|---|---|---|---|
| Gender | | Academics | |
| Male | 48 | Graduation Rate | 98 |
| Female | 52 | Mathematics Proficiency | 81 |
| Race | | Reading Proficiency | 91 |
| White | 72 | AP or IB Participation Rate | > 80 |
| Asian | 11 | IB Candidates | 15 |
| Hispanic | 10 | National Merit Finalists | 3.6 |
| Multi-Ethnic | 7 | Senior Class, *n* = 540 | |
| Black | 1 | Average SAT Score, Math | 629 |
| Other | < 1 | Average SAT Score, Reading | 627 |
| Free/Reduced Lunch | 11 | Average ACT Score | 27.6 |

*Note: 2018–2019 is the most recent year that the school published aggregated data.*

**Table 4.2**

*Demographics of the 2018 Cohort and their Diagnostic Scores and 1st Semester Grades*

| | | | Diagnostic Score | | 1st Semester Grade | |
|---|---|---|---|---|---|---|
| | *n* | % | *M* | *SD* | *M* | *SD* |
| Gender | | | | | | |
| Male | 70 | 56 | 34.53 | 10.60 | 81.07 | 12.91 |
| Female | 55 | 44 | 32.93 | 7.15 | 84.39 | 7.20 |
| Grade | | | | | | |
| 8 | 7 | 5.6 | | | | |
| 9 | 77 | 61.6 | | | | |
| 10 | 41 | 32.8 | | | | |
| Prerequisite Course Enrollment | | | | | | |
| Crescent HS | 8 | 6.4 | 32 | 2.45 | 72.77 | 16.69 |
| Highland MS (Public) | 31 | 24.8 | 35.06 | 5.89 | 81.85 | 13.71 |
| Peak View MS (Public Charter) | 52 | 41.6 | 37.19 | 11.65 | 84.46 | 9.83 |
| Other | | | | | | |
| In District | 26 | 20.8 | 29.93 | 5.05 | 83.80 | 7.23 |
| Out of District | 8 | 6.4 | 22 | 7.55 | 80.32 | 11.39 |

*Note: Pre-IB Algebra 2/3 is the first course in the high honors pathway. The diagnostic score is the score on the 75-question algebra pre-test given to students enrolled in that course during the first week of school. The 1st semester grade is the grade that students earned in the fall semester of that course. The prerequisite course enrollment is the school where students took Advanced Algebra 1, the prerequisite course for the pathway.*

For RQ2, both quantitative and qualitative data were collected through a voluntary pathway exit survey for all students who left the pathway during or immediately after the 2021 fall semester and select interviews with some of the female students who left the pathway within the last 2 years. These data resulted from nonprobability, purposeful, convenience sampling and the set of interviewees reflected maximum variation. The demographics of the survey respondents is summarized in Table 4.3.

**Table 4.3**

*Demographics of the Pathway Exit Survey Respondents, Fall 2021*

| *n* = 16 | *n* | % |
|---|---|---|
| Gender | | |
| Male | 7 | 43.8 |
| Female | 9 | 56.3 |
| Racial or Ethnic Identity | | |
| White | 10 | 62.5 |
| Asian | 2 | 12.5 |
| White and Asian | 2 | 12.5 |
| Middle Eastern | 1 | 6.3 |
| Course Dropped From | | |
| First Course | 6 | 37.5 |
| Second Course | 10 | 62.5 |

*Note: Participants supplied both gender identity and racial or ethnic identity through an open-ended question.*

It is important to note, especially in a chapter analyzing results and findings about gender, that non-binary students are often denied the ability to identify themselves accurately. The Williams Institute, a research center within the UCLA School of Law, estimates that approximately 1.2 million Americans identify as non-binary and approximately 1.4 million Americans identify as transgender (Flores et al., 2016). However the U.S. Census still does not collect information on either of these groups, mirroring the typical collection and presentation of education data. For example, while some Crescent High School students identify as non-binary, the official statistics for the school only identify students as male or female, as seen in Table 4.1.

Education research must expand the definition of gender to better account for and support these students. Their needs and experiences inherently differ from those of their

cisgender peers and continually excluding or misgendering them in data sets does them, and therefore education research as a whole, a significant disservice. There has been recent progress; the American Psychological Association (APA) recently released Inclusive Language Guidelines with their 7th edition style guide – a first step that demonstrates a desire to increase the visibility of non-binary people in education research.

This chapter reports and summarizes data with the gender categories used by the person or organization that collected it and can therefore reflect their biases. Additionally, some students come out as either non-binary or trans in high school, changing their identity to better reflect who they are, at no fault of the person or organization who collected data before the student felt comfortable enough to announce the change. These factors create discrepancies. For example, one of the students in the 2018 Cohort is non-binary, but in 2018, when the data on diagnostic scores and first semester grades were originally collected, they were included in the female gender group. Likewise, one transgender male student was also included in the female gender group in 2018 but no longer identifies as female. Because the data collected from the 2018 Cohort did not include names, it was impossible to determine which diagnostic score and first semester grade to include in the correct gender group for these two students. Therefore, both of their scores were included in the mean and standard deviation calculation for female students. However, in the survey and interview sample, as seen in Table 4.3, students identified their gender identity with an open-ended question. Though all students in this sample identified as either male or female, non-binary students would not have been forced to do so.

## Results and Findings

The results of the quantitative data and the findings of the qualitative data are organized in this section by research question, aligned with their intentional order.

### *Results for RQ1*

**Table 4.4**

*Enrollment and Change in Proportion of Enrollment in the First and Last Courses in the High Honors Mathematics Pathway by Gender for the 2018 Cohort*

| | First Course 2018–2019 | | Last Course 2021–2022 | | |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | Change |
| Male | 70 | 56 | 48 | 71.64 | +15.64% |
| Female | 55 | 44 | 18 | 26.87 | -17.13% |
| Non-binary | 0 | 0 | 1 | 1.49 | +1.49% |

*Note: Pre-IB Algebra 2/3 is the first course in the high honors pathway. Any eighth- or ninth-grade student who followed the pathway would be enrolled in either of the last courses: Calculus 2/3 or IB Math HL.*

Table 4.4 shows the enrollment changes by gender for the 2018 Cohort between the first and last course in the high honors pathway. Enrollment numbers for the first course include all students from the 2018 Cohort. All eighth- or ninth-grade students from this cohort who stayed in the pathway until the 11th or 12th grade respectively are in the last course during the 2021–2022 school year. This data point also includes the eighth-grade students from the 2019 Cohort. As such, comparing the change in percentages of male and female students is more reliable than the actual change in enrollment numbers. Finally, because the 2018 demographic source data did not include names, it was impossible to determine with which gender the non-binary student was originally included.

As seen in Table 4.4, the 2018 Cohort began the pathway in Pre-IB Algebra 2/3

with 56% male students and 44% female students. However by the final course, Calculus 2/3 or IB Math HL, only 26.87% were female and 71.64% were male. The percent of female students decreased by 17.13% while the percent of male students increased by 15.64% during the same time period.

**Table 4.5**

*Enrollment Changes in the First Two Courses of the High Honors Pathway, 2012–2022*

| | First Course | | Second Course | |
|---|---|---|---|---|
| | September | January | September | January |
| Total Enrolled | 1369 | 1231 | 926 | 863 |
| Attrition | | | | |
| from Previous Count | | -10.1% | -24.8% | -6.8% |
| from First Count | | -10.1% | -32.4% | -37.0% |

*Note: Attrition is measured as the difference between the percent of students who remain in the pathway at a given time compared to two past counts.*

Table 4.5 shows the cumulative enrollment changes from 2012 to 2022 for the first and second course of the high honors pathway, Pre-IB Algebra 2/3 and Elementary Functions/Calculus 1 respectively. The third course, AP Calculus BC, was not included because it is also part of the regular honors pathway. Because of this overlap in the pathways, the enrollment for AP Calculus BC was always higher than at any time during Pre-IB Algebra 2/3, which obscured attrition rates after the second course in the high honors pathway. Additionally, AP Calculus BC is also the last course in the pathway for sophomores who entered the pathway, preventing the use of enrollment numbers from this dataset to examine the attrition between the first and last courses.

As seen in Table 4.5, 1369 students have enrolled in the high honors pathway since 2012 and by the end of the second course only 863 remained. 37% of students left the high honors pathway in the first 2 years. The highest rate of attrition (-24.8%)

occurred between the two courses; the second highest rate of attrition (-10.1%) occurred between the fall and spring semesters of the first course. Both of the highest rates occur during or after the first course in the pathway.

The results for RQ1 suggest a disproportionate rate in attrition for female students and an overall rate of attrition concentrated during and immediately after the first course in the high honors pathway. These results are discussed further in the analysis section of this chapter.

***Results and Findings for RQ2***

**Table 4.6**

t-*Test Comparison of Male and Female Students' Diagnostic Scores and 1st Semester Grades from the 2018 Cohort*

| | Male | Female | *t* | *df* | *p* |
|---|---|---|---|---|---|
| *n* | 70 | 55 | | | |
| Diagnostic Score | | | 0.70 | 123 | .488 |
| Mean | 34.53 | 32.93 | | | |
| SD | 10.60 | 7.15 | | | |
| 1st Semester Grades | | | 1.24 | 123 | .219 |
| Mean | 81.07 | 84.39 | | | |
| SD | 12.91 | 7.20 | | | |

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 4.6 shows the two-tailed, heteroscedastic *t*-test comparison of male and female students for both their mean diagnostic scores and mean first semester grades from the 2018 Cohort. The diagnostic test is a 75-question intermediate algebra pre-test given to all students taking an advanced Algebra 2 course at Crescent, including the first course of the pathway. The raw scores are reported in this table. The first semester grades are the overall semester grades earned in the first semester of the first course of the

pathway and represent the percent grade out of 100.

As seen in Table 4.6, there is no statistically significant difference in the algebra background knowledge between the male (*M* = 34.53, *SD* = 10.60) and female (*M* = 32.93, *SD* = 7.15) students who enter the pathway, $t(123) = 0.70$, $p = .488$. Additionally, there is no statistically significant difference in the performance in the first semester of the course between the male (*M* = 81.07, *SD* = 12.91) and female (*M* = 84.39, *SD* = 7.20) students, $t(123) = 1.24$, $p = .219$. These results suggest neither a gap in algebra background knowledge nor an achievement gap in the first course of the high honors pathway. Further analysis appears in the analysis section of this chapter.

**Table 4.7**

t-*Test Comparison of Diagnostic Scores of Control vs Stereotype-Threat-Mitigating Experimental Group, Fall 2021*

| | Control | | | Experimental | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *n* | *M* | *SD* | *t* | *df* | *p* |
| Total | 49 | 20.65 | 6.23 | 51 | 20.44 | 9.14 | 0.14 | 98 | .891 |
| Male | 28 | 21.39 | 7.28 | 21 | 20.52 | 9.53 | 0.36 | 47 | .717 |
| Female | 21 | 19.79 | 4.73 | 30 | 20.37 | 8.92 | 0.27 | 49 | .789 |

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

*Note: The control group received the diagnostic exam with standard instructions. The experimental group received the diagnostic exam with specific stereotype-mitigating instructions adapted from Nguyen and Ryan (2008).*

Table 4.7 shows the two-tailed, heteroscedastic *t*-test comparison of diagnostic scores of all students in the first course of the high honors pathway in August 2021. Two of the four sections of this course received the standard exam instructions that emphasized the diagnosticity of the exam; this group is the control group. The other two sections received stereotype-threat-mitigating instructions adapted from Nguyen and Ryan (2008) and are labeled as the experimental group. As seen in Table 4.7, there is no

statistically significant difference between the students in the control (*M* = 20.65, *SD* = 6.23) and experimental (*M* = 20.44, *SD* = 9.14) groups, $t(98) = 0.14$, $p = .891$. Nor was there a statistically significant difference between the male students from the two groups, $t(47) = 0.36$, $p = .717$ or the female students from the two groups, $t(49) = 0.27$, $p = .789$.

The next two tables, Tables 4.8 and 4.9, summarize the results from the 16-question mindset quiz adapted from Dweck (2006) and included in the pathway exit survey. The quiz and scoring rubric appear in Appendix B.

**Table 4.8**

t-*Test Comparison of Mindset Scores of the Survey Respondents by Gender*

| | Male | Female | *t* | *df* | *p* |
|---|---|---|---|---|---|
| *n* | 7 | 9 | | | |
| Score | | | 0.42 | 14 | .681 |
| *M* | 52.7 | 54.7 | | | |
| *SD* | 6.7 | 10.7 | | | |
| Conversion | Growth with Some Fixed | Growth with Some Fixed | | | |

**p < .05, **p < .01, ***p < .001*

Table 4.8 shows the two-tailed, heteroscedastic *t*-test comparison of mindset scores of male ($n = 7$) and female ($n = 9$) survey respondents who left the high honors pathway during or immediately after the 2021 fall semester. As seen in Table 4.8, there is no statistically significant difference in mindset scores between the male (*M* = 52.7, *SD* = 6.7) and female (*M* = 54.7, *SD* = 10.7) survey participants, $t(14) = 0.42$, $p = .681$. Both mean scores convert to a growth mindset with some aspects of a fixed mindset.

**Table 4.9**

*Mindset Distribution of Male and Female Survey Respondents*

| | Male | | Female | |
|---|---|---|---|---|
| | *n* | % | *n* | % |
| Strong Growth | 1 | 14.3 | 3 | 33.3 |
| Growth with Some Fixed | 6 | 85.7 | 5 | 55.5 |
| Fixed with Some Growth | 0 | 0 | 1 | 11.1 |
| Strong Fixed | 0 | 0 | 0 | 0 |

Table 4.9 shows the mindset distribution of the male and female survey participants who left the high honors pathway in fall 2021. Most male (85.7%) and female (55.5%) survey participants have a growth mindset with some aspects of a fixed mindset and about twice as many female students (33.3%) have a strong growth mindset compared to the male students (14.3%). No male students had a primarily fixed mindset, while one female student had a fixed mindset with some aspects of a growth mindset.

Notably, Table 4.8 and 4.9 cannot facilitate generalizations about the mindset distribution of the whole school or even the students currently in the high honors pathway because the only students invited to take the pathway exit survey were students who left the high honors pathway during or immediately after the 2021 fall semester. Additionally, the sample size ($n$ = 16) was small.

**Table 4.10**

*Importance of Different Factors Considered by Female Survey Respondents When Deciding to Leave the High Honors Mathematics Pathway*

| | Importance | | | | |
|---|---|---|---|---|---|
| | 3-4 | 1-2 | 0 | *M* | *SD* |
| Balancing all my extracurriculars | 7 (78%) | 1 (11%) | 1 (11%) | 2.89 | 1.45 |
| Balancing all my academics | 6 (67%) | 3 (33%) | 0 (0%) | 2.76 | 1.20 |

| | | | | | |
|---|---|---|---|---|---|
| Afraid I'm not going to succeed | 4 (44%) | 5 (56%) | 0 (0%) | 2.44 | 0.88 |
| Not feeling smart enough | 2 (22%) | 7 (78%) | 0 (0%) | 2.00 | 0.71 |
| Feeling like I don't belong | 1 (11%) | 5 (56%) | 3 (33%) | 1.33 | 1.12 |
| Feel uncomfortable asking questions | 1 (11%) | 5 (56%) | 3 (33%) | 1.22 | 1.10 |
| Don't like my teacher | 0 (0%) | 2 (22%) | 7 (78%) | 0.33 | 0.71 |
| Who my classmates are | 0 (0%) | 1 (11%) | 8 (89%) | 0.22 | 0.67 |
| Not enough people like me in class | 0 (0%) | 1 (11%) | 8 (89%) | 0.22 | 0.67 |
| What class my friends are in | 0 (0%) | 1 (11%) | 8 (89%) | 0.11 | 0.33 |

*Note: Answers ranged from 0 (unimportant/ did not consider) to 4 (most important).*

Table 4.10 shows the importance of different factors female students considered when deciding to leave the pathway during or immediately after the 2021 fall semester. Respondents quantified the importance of each factor on a scale of 0 (unimportant/did not consider) to 4 (most important). The factors appear in the table in order of highest to lowest mean score. As seen in Table 4.10, the four most important factors were "balancing all my extracurriculars" (*M* = 2.89, *SD* = 1.45), "balancing all my academics" (*M* = 2.76, *SD* = 1.20), "afraid I'm not going to succeed" (*M* = 2.44, *SD* = 0.88), and "not feeling smart enough" (*M* = 2.00, *SD* = 0.71). Approximately 44% of the female students surveyed rated "afraid I'm not going to succeed" as either significantly (3) or most (4) important. Approximately 22% of the female students surveyed rated "not feeling smart enough" in these two categories. No female students rated either factor as unimportant (0). "Feeling like I don't belong" (*M* = 1.33, *SD* = 1.12) and "feel uncomfortable asking questions" (*M* = 1.22, *SD* = 1.10) were moderately considered while "who my classmates are" (*M* = 0.22, *SD* = 0.67), "not enough people like me in class" (*M* = 0.22, *SD* = 0.67), and "what class my friends are in" (*M* = 0.11, *SD* = 0.33) were rarely considered.

These results guided the design of the semi-structured interviews, the findings of which revealed four primary themes, summarized in Tables 4.11–14.

**Table 4.11**

*Major Theme: Defined by their Academic Performance*

| Theme | Code | Quote |
|---|---|---|
| Defined by their Academic Performance | Identity in Academics | "I definitely get a lot of validation from grades" |
| | | "I do base my self-worth and a lot of my self-confidence on my grades" |
| | | "I've always taken a lot of pride in my academics and trying to do well" |
| | Like Challenge | "If I am successful in a class that I know is really hard, it means a lot to me and so I feel very accomplished" |
| | | "I'm a pretty ambitious person and I like challenging myself and [I'm] also competitive and so I like doing more advanced things" |
| | | "I do enjoy being challenged learning new things" |
| | Good Grades are As | "I knew that I wouldn't be very happy if I was in a class that I was constantly struggling to get a grade that would make me happy. *Interviewer: What kind of grade is that?* I go for all As." |
| | | "It was a lot of stress for me to put on myself to get an A in such a difficult class" |
| | | "Obviously [the class I dropped into] is pretty easy but I kept my A" |
| | | "My parents have told me – just spend less time on it and get a B in the class instead – and my mind just doesn't work that way" |
| | | "[By taking the lower level class I could] get the same grade and weighted points on my transcript" |

Table 4.11 shows how the female students interviewed define themselves by their academic performance. They have a strong identity in academics, often going so far as

getting personal validation from grades and basing their self-worth and self-confidence on their grades. The students also like challenging themselves by taking advanced classes and used adjectives like “accomplished,” “ambitious,” and “competitive” when describing themselves.

As seen in the quotes about identity in academics, grades—more specifically, As—are clearly the primary indicator they use to define academic success. Quotes like “obviously [the class I dropped into] is pretty easy but I kept my A” and “my parents have told me – just spend less time on it and get a B in the class instead – and my mind just doesn’t work that way” demonstrate that anything less than an A is a kind of failure. When the students say “do well” and “get good grades,” they mean earning an A. Every student I interviewed is represented in this code.

**Table 4.12**

*Major Theme: Challenging Environment Revealed Barriers*

| Theme | Code | Quote |
|---|---|---|
| Challenging Environment Revealed Barriers | Low Self-Confidence | “I don’t really get things super quickly in math” |
| | | “[The class is] a higher level math but I was like – I can’t do this.” |
| | | “There were freshmen in this class that were way smarter and I was like – they’re just going to think I’m so silly.” |
| | | “So I went to my counselor in tears and I was like – hey I can’t do this.” |
| | | “I was stressed about it already and it didn’t feel like my level” |
| | | “I get really nervous when I’m going to ask a question like am I going to sound stupid?” |

| | | |
|---|---|---|
| | Increased Stress | "I was performing fine, like, well on the tests, but it just wasn't worth it to sacrifice the mental health to get a good grade." |
| | | "If it was going to affect your mental health then why do it?" |
| | | "I'm stressed and anxious and I totally hate it." |
| | | "My dad was like – hey I noticed that you're not very happy when you're stressed – and I was like – is anyone happy when they're stressed?" |
| | Perfectionism | "It was just a lot of work to do well" |
| | | "I just didn't want to half-ass math pretty much and like not understand it fully because I didn't have time for it and then move on to higher level math class and not understand." |
| | | "I'll try to do everything I can to get a grade. I've never cheated but I've always taken a really long time on homework if I don't get something." |
| | | "I was spending so much time understanding the material that I didn't want to spend less time." |

Table 4.12 shows how the challenging environment created by the high honors pathway revealed barriers for the female students interviewed. Low self-confidence was clear in statements like "[The class is] a higher level math but I was like – I can't do this," "there were freshmen in this class that were way smarter and I was like – they're just going to think I'm so silly," and "I don't really get things super quickly in math."

Students also expressed many concerns about their mental health and the increased stress: "I was performing fine, like well on tests, but it just wasn't worth it to sacrifice the mental health to get a good grade" reveals the impact of the increased stress

on the student's willingness to stay in the pathway. Other statements like "I'm stressed and anxious and I totally hate it," and "my dad was like – hey I noticed that you're not very happy when you're stressed – and I was like – is anyone happy when they're stressed?" show how stress influenced the students' views of the class.

Finally, all the students displayed some level of perfectionism through statements like "I was spending so much time understanding the material that I didn't want to spend less time," and "it was just a lot of work to do well." Clearly, students responded to the increased challenge of the high honors pathway by increasing effort.

**Table 4.13**

*Major Theme: Peers and School Culture, not Parents, Pressure Students*

| Theme | Code | Quote |
|---|---|---|
| Peers and School Culture, not Parents, Pressure Students | From Peers | "I definitely tend to compare myself, especially with [my friend] since we've been head to head with grades since kindergarten" |
| | | "There were freshmen in this class that were way smarter and I was like – they're just going to think I'm so silly." |
| | From the School | "I know [getting validation from grades] isn't exactly healthy and obviously I try and change it as much as possible but especially with the Crescent mentality of 'grades are your worth' it's hard to get away from that" |
| | | "There are definitely a lot of expectations at Crescent for getting into schools" |
| | Generally Not from Parents | "[My parents] have never cared about my grades or anything." |

| | |
|---|---|
| | "[My dad] was like – hey you have your whole life to take math classes and you don't have to take all of your top advanced math classes that you possibly can" |
| | "My parents have told me – just spend less time on it and get a B in the class instead – and my mind just doesn't work that way" |

Table 4.13 summarizes the external pressures that the female interviewees experienced—mainly from their peers and the school culture, rather than from parents. For example, one student said, "I definitely tend to compare myself, especially with [my friend] since we've been head to head with grades since kindergarten," while another imagined the younger students think she is stupid because she is older than them. The students also feel pressure from the school culture: "I know [getting validation from grades] isn't exactly healthy and obviously I try and change it as much as possible but especially with the Crescent mentality of 'grades are your worth' it's hard to get away from that."

On the other hand, none of the students expressed any pressure placed on them by parents, as exemplified by statements like "[my parents] have never cared about my grades or anything," and "[my dad] was like – hey you have your whole life to take math classes and you don't have to take all of your top advanced math classes that you possibly can."

**Table 4.14**

*Major Theme: Mathematics is not a Priority in their Future*

| Theme | Code | Quote |
|---|---|---|
| Mathematics is Not a Priority in their Future | Prioritizing Other Things | "I could keep up with it if I really wanted to" |
| | | "I didn't see a huge purpose in taking such an advanced class if I didn't really have to" |
| | | "Math was the class that I've always thought – well if I was going to drop down then it was always going to be math" |
| | | "I've realized that it's ok - that [math] doesn't have to be the highest thing. It can be prioritizing other things" |
| | | "If this was going to affect how colleges were going to see my applications and in the long run it wasn't really an issue" |
| | | "I can focus more on tennis and maybe that will get me more where I want to go to school" |
| | Looking to Others' Experiences | "I've come to the conclusion with a lot of my sister's help that life is a lot longer than you think and you are allowed to have fun and take it easy and not drown yourself in homework" |
| | | "I think my brother was a good example for me to watch because he didn't take [this pathway] but he got into a great college" |
| | How They See the Pathway Overall | "I've found the [high honors pathway] is mainly for people that know they want to be in a certain field when they go to college or they know what they are doing." |

| | |
|---|---|
| | "[The high honors pathway] is definitely not ideal for people that I guess aren't in – I don't want to say aren't in their career path already – but it's not ideal for people that are still wanting to explore all other subjects and activities in life" |

Table 4.14 shows how the female students interviewed view the role of mathematics and therefore the high honors mathematics pathway in their lives. As seen in the table, they do not view mathematics as a priority or necessary for their future goals. First, they have other priorities, exemplified in statements like "I didn't see a huge purpose in taking such an advanced class if I didn't really have to," and "I've realized that it's ok - that [math] doesn't have to be the highest thing. It can be prioritizing other things." Sometimes students cited other academic priorities ("Math was the class that I've always thought – well if I was going to drop down then it was always going to be math") and sometimes they noted extracurricular priorities ("I can focus more on tennis and maybe that will get me more where I want to go to school").

Students also looked to others' experiences as a guide for their own futures: "I think my brother was a good example for me to watch because he didn't take [this pathway] but he got into a great college." This perspective also connects to how the students view the high honors path in general—as a specialized track only for those who know they will need mathematics later on: "I've found the [high honors pathway] is mainly for people that know they want to be in a certain field when they go to college or they know what they are doing," and "I've found the [high honors pathway] is mainly for people that know they want to be in a certain field when they go to college or they know what they are doing" both exemplify this perspective. By holding these beliefs and

leaving the pathway, these students demonstrated that they already do not see mathematics as a priority for their future goals.

## Analysis

This study aimed to answer two research questions: In a large public high school in an affluent, highly-educated city, when are female students leaving the high honors mathematics pathway (RQ1) and why do they leave (RQ2)?

### *Answer to RQ1*

This study found a pattern of attrition in the high honors pathway at Crescent High School in which the female students leave the pathway at disproportionately higher rates than their male peers. For the 2018 Cohort, the proportion of female students dropped 17.13% between the first and last courses in the pathway while the proportion of male students increased 15.64% in the same period (Table 4.4). The rate of attrition is the most pronounced during and after the first course in the pathway. As seen in Table 4.5, from 2012 to 2022, 10.1% of the original cohort left the pathway after just one semester in the first course and by the start of the second course, nearly a third (32.4%) had dropped. Although students leave the pathway later in the sequence, the greatest rate of attrition occurs after the first course.

### *Answer to RQ2*

Prior chapters identified achievement and psychological factors as the main components that contribute to disproportionate rates of attrition for female students in STEM (Seymour & Hewitt, 1997). At Crescent High School, achievement does not directly affect attrition. Female students do not leave the pathway at higher rates because they are less well prepared than their male peers. Table 4.6 illustrates no statistically

significant difference in the algebra background knowledge between the male and female students of the 2018 Cohort (as measured by the diagnostic exam) nor is there a statistically significant difference between the two groups' overall first semester grades in the first course. This data suggests that achievement is clearly not the cause of the pattern of attrition of female students at Crescent High School.

However, there is evidence of psychological factors. Even without a statistically significant difference in mindset between the male and female students who left the high honors pathway in the fall of 2021 (Table 4.8), of the female students, two thirds displayed some aspects of a fixed mindset (Table 4.9). When asked to rate the importance of different factors when deciding whether to leave the pathway, all the female survey respondents said they were afraid they were not going to succeed and nearly half (44%) rated this fear as either significantly important or most important (Table 4.10). Another prominent factor was not feeling smart enough, which all female survey respondents considered, and nearly a quarter (22%) rated this feeling as either significantly important or most important when making their decision to leave (Table 4.10).

In combination with the survey data, the themes that emerged from the interviews formed a profile of the female students who leave the high honors pathway that flags the root causes of attrition at Crescent High School. As seen in Table 4.11, these female students define themselves by their academic performance, basing their self-worth on grades and maintaining excessively high expectations for success. One student summarized this mindset: "I do base my self-worth and a lot of my self-confidence on my grades," while another admitted, "I knew that I wouldn't be very happy if I was in a class that I was constantly struggling to get a grade that would make me happy. *Interviewer:

What kind of grade is that?* I go for all As." When these female students talk about good grades, they clearly mean As.

This mindset reveals barriers when they encounter challenging academic environments. The female students who leave the high honors pathway display unreasonably low self-confidence despite their achievement, report increased stress, and tend to compensate by working harder (Table 4.12). For example, one student said, "I don't really get things super quickly in math," despite being accelerated two grade levels and taking one of the most advanced courses. Another student said, "I was performing fine, like, well on the tests, but it just wasn't worth it to sacrifice the mental health to get a good grade," while another said, "I was spending so much time understanding the material that I didn't want to spend less time." All these internal barriers, revealed when the female students encountered a challenging academic environment, influenced their decision to leave.

These internal, psychological barriers are not the only pressures the female students experience; they feel pressure from peers and the school culture, but generally not their parents (Table 4.13). One student said, "I definitely tend to compare myself, especially with [my friend] since we've been head to head with grades since kindergarten," while another spoke of the school culture: "I know [getting validation from grades] isn't exactly healthy and obviously I try and change it as much as possible but especially with the Crescent mentality of 'grades are your worth' it's hard to get away from that." Parents, on the other hand, were hands-off, letting the students make their own decisions without additional pressure. Some even recommended that their student leave the pathway: "[My dad] was like – hey you have your whole life to take math

classes and you don’t have to take all of your top advanced math classes that you possibly can.” The pressure from peers and school culture is significant and was a factor in their decision to leave the pathway.

The final motivational factor that emerged from the interview findings was that the female students who leave the high honors pathway do not see mathematics as a priority in their future. Table 4.14 includes many examples. Students said things like, “I could keep up with it if I really wanted to,” and “I didn’t see such a huge purpose in taking such an advanced math class if I didn’t really have to” and “math was the class that I’ve always thought – well if I was going to drop down then it was always going to be math.” They also view the high honors mathematics pathway as only for students who already have career goals that involve mathematics. Their decision to leave implies they do not identify as one such student.

**Summary**

The female students at Crescent High School leave the high honors mathematics pathway at a higher rate than their male peers and most of this attrition occurs during or after the first course in the pathway. Psychological and motivational factors contribute to this pattern, rather than achievement. The female students who left the pathway base their identity around academic performance and have excessively high standards, a mindset that reveals internalized barriers when faced with challenging material. These factors, in combination with the external pressures they feel and a view that mathematics is not a priority in their future, causes female students to leave the high honors mathematics pathway at disproportionately higher rates than their male peers.

# CHAPTER 5

# DISCUSSION AND RECOMMENDATIONS

Crescent High School has a pattern of disproportionate attrition of female students in the high honors mathematics pathway that culminates in only a quarter (26.87%) of the students in the final course of the pathway being female (Table 4.4). The implications for educational and economic equity are significant, given that mathematics is a gatekeeper to STEM fields (Cobb & Hodge, 2011; Stinson, 2004), fields that earn graduates $15,500 more annually on average (de Brey et al., 2019). For women, the gap is even wider, as women in STEM earned 33% more than their comparable female peers in non-STEM careers (Beede et al., 2011).

While attrition of female students in STEM degree programs and careers is well documented (Beede et al., 2011; de Brey et al., 2019; Seymour & Hewitt, 1997; Seymour & Hunter, 2019), the pattern is less well understood at the secondary level. Understanding this pattern and its causes at Crescent High School is a fundamental step in designing effective and sustainable interventions and policies that target this disparity. Researchers agree that no one root cause explains the attrition of female students in STEM; instead, multiple interwoven factors contribute to the pattern as a whole (Dweck, 2007; Seymour & Hewitt, 1997; Steele, 2010; Steele & Aronson, 2004).

The theoretical framework of this study, therefore, also consisted of multiple interwoven theories to better inform the research questions than a single theory alone.

Attribution theory and the implicit theories of intelligence frame how students view success, failure, challenges, and intelligence in general and influence both achievement and motivation (Dweck, 2006; Kloosterman, 1988). The theory of stereotype threat explains one way stereotypes can influence achievement and motivation in challenging environments (Steele, 1997). Finally, the self-worth theory of motivation assumes that students construct their achievement goals to maintain a sense of worth in a society that values competency and success (Covington, 1992).

Answering the two research questions within this framework required an explanatory mixed methods approach, first analyzing the pattern of attrition using quantitative enrollment data from two sources: longitudinal whole-school enrollment data and enrollment data from a specific cohort of students in the pathway. The demographics of each sample appear in Tables 4.1 and 4.2 respectively. The analysis of these two sources answered the first research question: in an affluent, highly educated city, when are female students leaving the high honors mathematics pathway (RQ1)? Although female students make up 52% of the student body, only 44% of the students in the first course of the pathway are female. By the end, female students made up 26.87% of the students enrolled in the final course—a 17.13% decrease in representation while, during the same time period, the proportion of male students increased 15.64%. This rate of attrition is the most pronounced after the first course in the pathway, when nearly a third (32.7%) of the original cohort has already dropped before the start of the second course.

These results were then explained through both quantitative and qualitative measures. Diagnostic scores and Likert-scale questions in the pathway exit survey were quantitative and guided the design of the qualitative semi-structured interviews and the

selection of the interviewees. These sources provided answers to the second research question: why do female students leave the high honors mathematics pathway (RQ2)? The results and findings demonstrate that the female students do not leave the pathway because of an achievement gap. After all, there is no gap; there is no statistical difference between male and female students in either algebra background knowledge or first semester grades. Instead, psychological and motivational factors are the underlying causes. The female students who leave the pathway have a strong identity in academics and hold excessively high expectations for success. This mindset reveals internal barriers when the female students encounter challenging academic environments, like unreasonably low confidence, increased stress, and tendencies toward perfectionism. While they report pressure from peers and the school culture, the female students are not pressured by parents. Finally, one of the most prominent and consistent themes across the interviews was that the female students who leave the high honors pathway do not view mathematics as a priority in their future. All of these psychological and motivational factors contribute to the disproportionately high rate of attrition of female students in the high honors mathematics pathway at Crescent High School.

**Results Related to Existing Literature**

The study's results connect to existing research. Some results are consistent with the background literature while some are surprising. Each open code that emerged from the qualitative data analysis indicated one or more of the three hypothesized causes of attrition: mindset, stereotype threat, and a fear of failure. This section discusses the extent to which they indicate each cause.

### *Connecting Answers for RQ1 to the Literature*

This study detected a concerning pattern of attrition in the high honors mathematics pathway at Crescent High School, even from the beginning of the first course of pathway. In a school with 52% female students, only 44% of the students in the first course are female. By the end of the pathway, only 27% of the students are female—a 17% decrease in representation. This pattern is not surprising because it is mirrored in higher education, where women are less likely to enroll in STEM degree programs despite equal qualifications as their male peers (Beasley & Fischer, 2012; Seymour & Hunter, 2019; Vooren et al., 2022). From there, they are less likely to continue in their STEM course of study and less likely to work in STEM after they earn a STEM degree (de Brey et al., 2019; Martinez & Christnacht, 2021). The results of this study show the exact same pattern of attrition.

Initially, these results might seem surprising. After all, research shows no difference in enrollment by gender in advanced mathematics courses in high school (Hyde et al., 2008; Lacampagne et al., 2007). However, the high honors pathway at Crescent starts with Algebra 2 and ends with Calculus 3. The pace and rigor of the courses are much more akin to those in higher education than the standard honors pathway offered in previously studied high schools; therefore, it is reasonable to expect more similarities between the patterns in higher education and the high honors pathway.

The rate of attrition is not constant throughout the high honors pathway and is the highest during and after the first course: 10.1% of students who begin the pathway leave after the first semester, while another 24.8% leave after the second. By the start of the second course in the pathway, 32.4% of the original cohort has already dropped. This

trend is unsurprising, as the highest rates of attrition in college-level STEM degree programs occur in the first year (Seymour & Hunter, 2019). Ellis et al. (2016) found, in mathematics specifically, that college women were 1.5 times more likely than their male peers to drop mathematics after Calculus 1. This affect is even more pronounced for high achieving women where twice as many women as men who earned an A or B in Calculus 1 abandoned the idea of taking Calculus 2 (Bressoud et al., 2015). Calculus 1 is often described as a gatekeeping course for many STEM degrees and the first course in the high honors pathway is often described the same way by teachers, students, and administration.

### *Connecting Answers for RQ2 to the Literature*

This study investigated two types of factors—achievement and motivation—to explain why female students leave the high honors pathway at higher rates than their male peers and found no evidence of an achievement gap; there was no statistical difference in the algebra background knowledge or first semester grades of the female and male students. This result is surprising because even though the average school district has no gender achievement gap in mathematics, affluent, highly-educated, and predominantly White districts, like Crescents', do and they favor boys (Reardon et al., 2016). Studies have also shown that the achievement gap is the most pronounced at the highest levels of performance (Ellison & Swanson, 2018; McGraw et al., 2006). Crescent High School is in an affluent, highly-educated and predominantly White community, and the students enrolled in the high honors pathway represent the highest level of performance. A lack of evidence of an achievement gap is therefore surprising.

This result, however, does not mean that achievement had no effect on the pattern

of attrition, just that the female students are equally prepared for the high honors pathway and perform equally well as their male peers. Perception of achievement is also an important factor (Seymour & Hewitt, 1997) and connects academic performance to the psychological and motivational factors that influence attrition.

The results and findings of this study revealed several prominent psychological and motivational factors explaining why female students leave the high honors pathway. First, the female students who leave define themselves by their academic performance, often basing some of their self-worth on grades, echoing literature that shows female students are more affected by grades than male students (Ost, 2010) and are more perfectionist about grades (Seymour & Hunter, 2019). This finding also demonstrates how the perception of achievement can affect attrition; while some teachers, parents, and administrators might view Bs as acceptable, these female students do not. Seymour and Hunter (2019) found that there was an underlying assumption that there was no space between perfection and failure and that there is "only one very narrow and extremely high standard of preparation than can lead to success," (p. 539). For women in particular, these extremely high academic expectations often destroyed feelings of belonging. This perspective affects attrition in significant ways. High-achieving women in STEM degree programs have greater difficulty easing the stress of unrealistically high expectations so switching pathways allows them to regain self-esteem without having to confront the criteria they are using (Seymour & Hunter, 2019). This attitude is clearly seen by how the interviewed female students define success as all As and that for some of them, switching to a lower math class provided that protection to their identity even though they considered the new, lower course as borderline too easy.

Defining themselves by their academic performance is evidence of a fixed mindset, as students with fixed mindsets believe the ultimate goal of learning is to demonstrate intelligence through performance standards rather than learning goals (Dweck, 1986). In this study, two-thirds of the female students who left the pathway during or immediately after the 2021 fall semester had some aspects of a fixed mindset. Defining success as earning all As also demonstrates unreasonably high academic expectations, leaving no room for improvement, and indicates self-handicapping, a self-protective mechanism whereby students create a barrier to success for themselves and thus provide a preemptive excuse for potential failure (Covington, 2000). Self-handicapping is a hallmark of students who have a fear of failure (Fried-Buchalter, 1992; Thompson et al., 1998). Finally, caring about doing well, which these students absolutely do, is one of the required aspects of a threatening environment that can engender the negative effects of stereotype threat (Aronson et al., 1999; Steele, 2010).

A strong identity in academics and a high bar for success are not inherently debilitating. However, when challenging material is present and success is difficult, motivational beliefs become highly predictive of achievement (Grant & Dweck, 2003). While perfectionism in grades can be a motivator to achieve, it can also fuel maladaptive behaviors and have an emotional toll (Flett & Hewitt, 2012). This is especially true for female students because they are more likely to have extrinsic measurements of identity, like academic performance, than their male peers (Seymour & Hunter, 2019). Seymour and Hunter (2019) found that high-achieving STEM students, especially women, who are unwilling or unable to dissociate their grades from their identity are at particular risk for leaving STEM pathways. Even for stereotype threat, the nature of the task changes the

effect. On easy tests, normal conditions for stereotype threat actually motivated students and improved scores. However when the task was challenging, stereotype threat negatively affected outcomes (O'Brien & Crandall, 2003). The high honors pathway is this challenge, and three barriers emerged from the findings—low self-confidence, increased stress, and perfectionism. Each barrier indicates at least two of the three causes for attrition hypothesized in this study: mindset, stereotype threat, and the fear of failure; low self-confidence was an indicator of all three.

Low self-confidence is the least surprising because its evidence in the literature for female students and mathematics is strong (Burkley et al, 2010; Dweck, 2007; Degol et al., 2018; Else-Quest et al., 2013; Herbert & Stipek, 2005). The impact of low self-confidence on attrition is also robust. Seymour and Hunter (2019) reported that lost confidence was the most significant negative consequence experienced by people who decided to leave STEM degree programs, especially for women, where loss of confidence contributed to 61% of decisions to switch majors (Seymour & Hunter, 2019). Ellis et al. (2016) drew particular attention to Calculus 1 which they claim weeds out female students through lack of confidence rather than actual mathematics capability. Therefore, low self-confidence was understandably a primary factor in why female students at Crescent leave the high honors pathway at higher rates than their male peers.

Of the three main findings, low self-confidence is the only indicator of all three hypothesized causes. When faced with challenging material, a person with a fixed mindset may reduce perceptions of ability, which all interviewed female students demonstrated, and therefore reduce expectancy for success (Burnette et al., 2013). Expectancy for success then guides behavior (Weiner, 1985), like the decision to leave a

challenging environment prematurely, which the interviewed students did. This finding echoes Cramer and Oshima (1992), who found that ninth-grade, high-achieving female students—a majority of the students surveyed and interviewed in this study—attributed failure to ability: a textbook indication of a fixed mindset. Low self-confidence is also prevalent in the body of research on stereotype threat, where Jouini et al. (2018) links stereotypes to higher psychological risk that can lower self-confidence. This outcome occurs for women in mathematics even when performance is high (Linn & Hyde, 1989). Because the risk of disappointment is greater for female students in mathematics than male students, it contributes to greater underconfidence and risk aversion, as seen in this study, causing female students to make less ambitious choices in order to reduce psychological risk (Jouini et al., 2018). Finally, failure-fearing students are characterized by their self-doubt and fear rather than their resilience and enthusiasm for learning (De Castella et al., 2013). The maladaptive protection strategy that students who fear failure tend to adopt is defensive pessimism, a strategy in which students hold unreasonably low expectations for their own abilities (Covington, 2000). This strategy causes students to make less ambitious choices, hoping to avoid future anxiety (Cantor & Norem, 1989). The findings from this study show just how low those expectations are.

Increased stress was also an important finding and is consistent with the literature, as female students experience higher levels of stress than their male peers (American Psychological Association, 2014). Additionally, perfectionism in grades, as discussed previously, has been associated with higher risk for anxiety and depression (Tomasi et al., 2019). Increased stress is also an indication of both stereotype threat and a fear of failure. This finding may indicate stereotype threat because one of the primary mechanisms that

stereotype threat works through is stress arousal that directly impairs prefrontal processing (Ben-Zeev et al., 2005; Schmader et al., 2008). People under stereotype threat have been shown to experience increased blood pressure and heart rate, physiological indicators of increased stress (Blascovich et al., 2001; Croizet et al., 2004; Murphy et al., 2007), as well as a neuroendocrine stress response (Townsend et al., 2011). Increased stress seems to be an even stronger indicator of a fear of failure, as students who fear failure are at a higher risk for emotional fatigue and burnout (De Castella et al., 2013) and experience higher anxiety and unstable self-esteem (Covington, 1992). When presented with challenges or setbacks, they often lack resiliency (Martin et al., 2001; Martin & Marsh, 2003). All of these indicators of a fear of failure—emotional fatigue, high anxiety, unstable self-esteem, and a lack of resiliency—manifested in this study. Seymour and Hunter (2019) found that many people who switched out of STEM majors reported depression, high levels of stress, chronic anxiety, feeling lost and overwhelmed, or living with intolerable fear. Additionally, failure-fearing students tend to adopt defensive pessimism to stifle the possibility of overwhelming, debilitating anxiety caused by challenging events (Cantor & Norem, 1989). The motivational effects of a fear of failure can cause high levels of anticipatory anxiety, leading students to avoid mathematics as much as possible (Lyons & Beilock, 2012; Maloney & Beilock, 2012). High levels of anticipatory anxiety are clearly present in the findings.

How students cope with the challenge of the high honors pathway is at the crux of this problem of practice. According to Dweck (2006):

> It is here, at the top of the ability distribution, that the gender difference in math emerges. Thus, it is possible that at least part of the emerging difference in math

is a gender difference in coping with setbacks and confusion rather than a gender difference in math ability. (p. 48)

The primary way that female students in this study initially coped with the challenge of the high honors pathway was to work harder. This finding is unsurprising because school-aged girls of all ages tend to have higher overall self-discipline, start their homework earlier in the day, and spend almost twice as long completing it than their male peers (Duckworth & Seligman, 2006). This finding also indicates a fear of failure, as students with a high success orientation and a high fear of failure are more likely to respond to their fears by increasing effort (De Castella et al., 2013). However, in challenging environments, working harder does not necessarily guarantee results, especially if a student has a fixed mindset or a fear of failure. For example, students with fixed mindsets are more vulnerable to a loss of effectiveness when they encounter challenging material (Grant & Dweck, 2003), as are students who fear failure (Lerch et al., 2018), showing slower information accumulation and lower learning rates, even under conditions of primarily positive feedback. Hence, Covington (1992) argued that increasing pressure on students to try harder during risk of failure will only exacerbate the problem. This supports the findings in this study, where female students responded to challenge by working harder without necessarily seeing the fruits of their labor. Mirroring the findings of Seymour and Hunter (2019) who found that high-achieving female students were more likely to conclude that STEM was not worth the effort and stress required, the female students interviewed ultimately felt that staying in the pathway was not worth the increased effort.

Pressure was another significant finding. Female students who left the pathway

experienced pressure from peers and from school culture. These results are not surprising. Peer effects is another commonly studied cause of attrition because studies suggest that women's academic choices are more affected by their peers and role models than men's (Bagès et al., 2016; Fischer, 2017; Lim & Meer, 2017). Additionally, when facing challenging material, students with fixed mindsets often worry about *appearing* unintelligent or incompetent, which may shape Crescent's pressure-cooker academic culture, mentioned frequently in the interviews. One surprising finding is that parents seemed exempt; no one in the study mentioned feeling any pressure by parents to stay in the high honors pathway. This pattern was unexpected because parental aspirations are strongly linked to academic achievement across cultures and ages (De Civita et al., 2004; Neuenschwader et al., 2007; Sjaastad, 2012; Seymour & Hunter, 2019; VanMeter-Adams et al., 2014) and only when those aspirations exceed expectations are there negative effects on mathematics achievement (Murayama et al., 2016). Evidence of this overaspiration was therefore expected but not found. Instead, parents of the interviewed female students were hands-off and some were even the ones to suggest leaving the high honors pathway.

Finally, the female students who left the high honors pathway showed little intrinsic interest in mathematics or a desire to prioritize mathematics in their future, which is one of the most significant findings because intrinsic interest directly connects to much of the research on female attrition in STEM (Wang et al., 2017). Seymour and Hewitt (1997) demonstrated that the top three reasons why female students left STEM degree programs all related to a lack of interest in STEM and the rejection of STEM careers. This is especially true of high-performing women, 67% of whom cited loss of

incoming interest as the reason they left STEM degree programs (compared to only 46% of their male peers) (Seymour & Hunter, 2019). On the other side of the spectrum, female students who decided not to leave showed the highest intrinsic interest, higher even than their male peers. Intrinsic interest, therefore, could be a significant wedge between the female students who stay in the pathway and those who do not, reflected in the way the female students who leave the pathway view its purpose—as a place only for those who already have explicit mathematics-related career goals. Mindset and stereotype threat could be partially responsible for this finding. Women who believe their mathematics skills are fixed show less identification and interest in mathematics and less desire to pursue a mathematics-related field (Burkley et al., 2010). Additionally, setting performance goals, rather than learning goals, indicates a fixed mindset and is associated with lower intrinsic interest and enjoyment (Rawsthorne & Elliot, 1999; Shim et al., 2013). Stereotypes might also be at play. Research has shown that gender stereotypes in mathematics are acquired as early as second grade and influence self-concept prior to ages when actual differences in mathematics achievement are evident (Cvencek et al., 2011). This weaker self-concept in mathematics reduces interest in future academic courses and careers (Denissen et al., 2007; Frome et al., 2006). Even mathematical anxiety, which is associated with decreased engagement in STEM careers (Hembree, 1990), could be influential.

**Recommendations for Practice**

The purpose of this study was to investigate when and why female students leave the high honors pathway at disproportionally higher rates than their male peers with the ultimate goal of using the results and findings to propose recommendations for practice.

Due to scant literature on attrition of female students in secondary high honors mathematics pathways, understanding the pattern was necessary before designing any interventions. Finite funding and energy in education create pressure to make any policy or practice change as effective and sustainable as possible. Additionally, in Crescent's school district, these types of changes can be subject to momentum shifts and redirected focus, further increasing the pressure to design and implement successful changes and interventions on the first attempt. Because scholars like Dweck (2006) and Jouini et al. (2018) believe that the difference in mathematics emerges at the top of the ability distribution, policy changes and interventions "should not only aim to get *more* girls to participate, but they should especially target the most able girls" (Jouini et al., 2018, p. 42). Two attrition patterns need direct attention: the fact that female students are already underrepresented in the first course of the pathway and the fact that they are increasingly underrepresented in every subsequent course. The recommendations for practice include one primary policy change and one primary intervention.

The policy recommendation is to change the way courses are recommended at Crescent so that recommendations are only required to enter the pathway. Currently, to earn a recommendation to continue in the high honors pathway, students must earn an 83% or higher average on their unit exams. Students can elect to stay in the pathway without a recommendation, but the stakes are higher and the risk increases. While someone with a recommendation can decide to drop to a lower course within the first few weeks of the year, someone who overrode the recommendation is not allowed to leave until at least the semester mark and even then they are last priority if there is limited space in the lower course. As seen from this study, the female students who leave the

pathway set extremely high expectations for their academic performance, which increases their perceived risk of failure. The current override policy heightens this risk even more because it takes away a safety net. Additionally, telling students that an 80% exam average is not good enough to earn a recommendation to continue in the pathway is telling them that a B is not good enough, thus strengthening their belief that good grades are only As. Instead, once a student is in the pathway, recommendations should no longer be required. Each course in the pathway has the same pace and rigor and therefore the students know what to expect and can adjust year to year. The survey data (Table 4.10) clearly show these students are very involved in academics and extracurriculars. Allowing them to adjust this balance the following year is allowing them to cope with the challenging environment in a healthier and more effective way than simply telling them to work harder, a tactic shown to be counterproductive (Covington, 1992).

Continuing on this policy change, conversations about recommendations into the pathway need to happen at the middle school level. Because a pattern of unequal attrition already exists by the start of the first course, Crescent should bring eighth-grade math teachers who make the initial recommendations into the conversation so they are aware of the pattern and also how their female students interpret their view on the pathway. The same is true of counselors because female students tend to make decisions about academics using guidance from other people more so than their male peers (Bagès et al., 2016; Fischer, 2017; Lim & Meer, 2017). Additionally, the research on implicit bias against female students by mathematics teachers in tracking decisions is robust (Benner & Graham, 2011; Farkas, 2003; Nürnberger et al., 2016). This bias is present even for female mathematics teachers and teachers who do not believe they are biased in the first

place (Copur-Gencturk, 2019, 2020). Removing recommendations from inside the pathway and changing the conversation about entering the pathway can mitigate the current policy's unintended consequences.

Policy changes are not the only solution. One intervention recommendation is to create a support group for female students in the high honors pathway. Because many of these students already feel as if they do not have enough time, this support group must not require more of their time. Crescent has a ninth-grade seminar program—similar to a homeroom—that meets for 1.5 hours once a week in the first semester of students' ninth-grade year, when they hear announcements, learn about the school, and have time to do homework. These seminars are supervised by a teacher but run by a group of four to five 11th- and 12th-grade leaders. Because some students are already intentionally grouped into specific seminars, there is precedent to do the same for female students in the high honors pathway. Attrition in STEM is a positive feedback loop; exposure to high-achieving female peers in mathematics courses increases the likelihood that a female student chooses a STEM track in high school (Mouganie & Wang, 2020). This seminar could be the exposure they are not getting in class. Additionally, the leaders running this seminar would also be female students in the high honors pathway. These leaders could be the role models whom the younger female students are missing. One recommendation to increase the potential mentorship between the leaders and the ninth-grade students is to assign each leader a smaller cohort of within the whole group. Having the leaders send encouraging text messages on days of tests and randomly throughout the week can be a great way to build a positive relationship.

Beyond the structure of the seminar, meeting once a week gives Crescent an

opportunity to organize intentional lessons designed for these specific students and their needs, including explicit instruction on stereotype threat and mindset, both shown to mitigate the effects of stereotype threat and promote growth mindsets. Steele (2010) and Dweck (2006) are great resources for the design of these lessons. This seminar would also be a great opportunity to bring in adult women from the local STEM community to talk about their experiences, careers, and passions, introducing more potential role models. Seymour and Hunter (2019) found that a lack of incoming knowledge about the nature of STEM majors and options within STEM fields is one of the leading contributors to attrition in higher education. Finally, it is imperative to address the psychological factors that influence the female students' decision to leave the high honors pathway, factors like a focus on As, low self-confidence, increased stress, a tendency for perfectionism, pressure from peers and school culture, and a decreased interest in mathematics-related fields. One solution could be targeted support group sessions where students speak candidly about their experience in the high honors pathway regarding one or more of these factors. Ensuring success of these support group sessions warrants additional considerations. First, the seminar must build a safe space for these students before asking them to be vulnerable; having the leaders share their experiences with these factors first can help the ninth graders feel more comfortable being vulnerable themselves. Depending on the factor being discussed, bringing in outside moderation, like a counselor or another mental health professional, might be necessary. These psychological factors are real and need to be discussed openly and safely, not only to close the attrition gap, but also to provide the support that these female students likely need.

Although this proposed intervention may be a large undertaking, even implementing some of its components can be useful even if the overall seminar support group is not possible. For example, assigning mentorships between female students in the first and last courses in the pathway is a small intervention that could potentially have lasting effects on the students' futures.

**Limitations**

This study had several limitations. First, the samples themselves are not ideal. The longitudinal data did not include demographic data therefore it was impossible to establish a gendered pattern of attrition from this source and isolate the high honors students from the honors students in the third source. Instead, a source with a smaller sample size—the 2018 Cohort—was necessary. This same limitation arises in the pathway exit survey data. This is the first year the pathway exit survey was administered; therefore, the sample is extremely small. All results from this source must be considered with this limitation in mind. Additionally, Crescent's district restricts access to previous course data for all teachers, allowing them to only see the current year, and restricts administrators' access to only current students, therefore repeating the analysis of the 2018 Cohort on other cohorts to establish redundancy and increase sample size was impossible.

Another limitation was that the procedure to investigate stereotype threat targeted performance on the diagnostic exam at the beginning of the 2021 fall semester, before the lack of statistical difference historically between the scores of female and male students was known. The results of this experiment are in Table 4.7. The background literature shows psychological effects of stereotype threat however this study did not

systematically investigate them. Instead, the presence of stereotype threat was deduced using indicators from the qualitative data. Additionally, although the stereotype-threat-mitigating script from Nguyen and Ryan (2008) was used, the placement of students in either the control or the stereotype-threat-mitigating experimental group was done by class periods, not randomly. Because of these reasons, the quantitative results on stereotype threat were inconclusive.

One limitation on the interviews was the timing. Students were interviewed in December 2021 and January 2022, sometimes months after they made their decision to leave the high honors pathway. This gap could have affected what the students remembered about their decision-making process. Additionally, all interviewees left the pathway either during the fall semester or immediately after. Only one left the pathway after the end of the first course, and this experience was unique in that she changed her mind after a week and entered the pathway again only to change her mind after a few more weeks and leave again. One way to remedy the influence of timing and to better capture the experience of leaving the pathway between courses would have been to interview female students at the end of the first course as soon as possible after they made their decision.

My positionality is also potentially a limitation for the interviews. Three of the four female students were former students, which could have influenced what they decided to reveal, especially when speaking about teachers in the pathway. Because few students surveyed considered who their teacher was or would be when making the decision (Table 4.10), I intuited positionality was not as significant a limitation as expected. However, that does not rule out the possibility that positionality interfered with

the validity of the data.

Finally, the COVID-19 pandemic created a limitation. The students interviewed in this study were from the 2019, 2020, or 2021 Cohorts, which all experienced some disruption to the first course of the pathway because of the pandemic, especially the 2020 Cohort who took the first course in a quarter system schedule, had fewer extracurriculars, and received significant academic support that decreased the overall rigor of the course. This circumstance potentially affected their ability to cope with the normal expectations of the high honors pathway once school returned to in-person classes during the 2021 fall semester. The 2018 Cohort was the most recent group of students that experienced the first course of the pathway without any disruption to the traditional school system because of the pandemic, but these students were not interviewed because their decision to drop was less recent. Therefore, the pandemic impacted all survey and interview data in unknown ways.

**Recommendations for Future Research**

The first recommendation for future research is to expand the investigation of RQ2 by interviewing different groups of people, allowing a more direct comparison to be made. For example, interviewing female students who stayed in the pathway could illuminate how their experience in the pathway was different than the female students who left. What supports, resources, or attitudes do they have that make them persist? Additionally, investigating the intersectionality of race and gender in the attrition pattern at Crescent is vital. This study focused on gender only; however, of the female students in the final course, most are either Asian or White and Asian. Intersectionality refers to the different experiences that White, Asian, and White and Asian female students have at

Crescent. These identities are not additive; Asian girls have different experiences than both Asian boys and White girls. How do the achievement and psychological factors that affect attrition change for female students from different racial or ethnic groups than those interviewed? Which factors discovered in this study are the same? Which factors are different? Many potential research questions regarding intersectionality could yield better understanding of the attrition pattern at Crescent.

The next recommendation is to expand this study into other schools with similar high honors pathways as Crescent to see if this pattern is transferable to schools in similar settings. High honors pathways are less common than traditional honors pathways, yet the competitive educational environment stoked by school choice and open enrollment may create some incentive for schools to set themselves apart by offering high honors pathways like Crescent. It is imperative, however, that for all the benefits that this pathway can provide, that issues of inequity are thoroughly investigated.

Two additional recommendations for future research stem from two of the limitations. Further understanding the effect of stereotype threat on this population requires expanding the investigation away from using achievement data and toward the psychological factors as with Jouini et al. (2018) but for secondary students. This approach would provide a more complete picture of how stereotype threat could possibly influence the attrition pattern, which could then guide additional policy changes and interventions. The second recommendation derived from the limitations is a systematic examination of the attrition pattern and recommendation policy happening at the middle schools in the district. This study found, unexpectedly, that female students were already underrepresented in the first course of the pathway at the high school level, which implies

an earlier pattern of differential attrition. However, this pattern is unknown. The students in this pathway are twice-, or three-times-accelerated above their grade level in mathematics; how? What role do the teachers, parents, and students have in this decision? How do these roles differ between the two main feeder middle schools? What are the recommendation policies? Answering such questions could reveal the root of the attrition pattern.

Finally, if any policy changes or interventions recommended from this study are implemented, recollecting and reanalyzing the data in a systematic way is critical to establishing the effectiveness of the changes. This diligence would increase the transferability of the practices so that similar schools and pathways can apply the same changes with more hope of success. Additionally, if the changes were not effective, other alternatives can be attempted instead. The overall goal is actual change, not just the attempt at change. Continued data collection and analysis is salient.

**Summary**

This study and its findings are significant because most research on attrition of female students in mathematics occurs at the university level, leaving secondary schools with few research-based recommendations for practice. The purpose of this explanatory mixed methods action research study was to better understand the specific pattern at Crescent High School, a large, public high school in an affluent, highly-educated city, by investigating when and why the female students leave the high honors mathematics pathway.

Many of the results and findings were consistent with the research: most students leave the high honors pathway during or after the first course, and the female students,

setting extremely high academic expectations for themselves, report low self-confidence, increased stress, perfectionist tendencies, pressure from peers and school culture, and a lack of interest in pursuing a mathematics-related field. All these factors point to some origin in mindset and a fear of failure and possibly stereotype threat. Other results and findings were surprising. Unlike Crescent’s district and other affluent, highly-educated, and predominantly White districts, which have an achievement gap in mathematics that favors male students, there is no achievement gap in the high honors pathway at Crescent. This is true for both measures of achievement used in this study: the algebra diagnostic exam and the first semester grades. Thus, female students do not leave the pathway because they are less well prepared than their male peers. Additionally, all the female students interviewed mentioned feeling no pressure to stay in the pathway from their parents, who were generally described as supportive of whatever decision their daughters decided to make. Like the lack of an achievement gap, this finding was also inconsistent with the literature.

Based on these results and findings, several recommendations for practice were made. The first was a policy change that would alter the course recommendation process within the pathway. Partnering with middle school teachers and counselors was a crucial part of this recommended policy change. A major intervention for the female students was also recommended in creating an intentional seminar class that would meet weekly for the first semester of ninth grade, purposely grouping female students in the high honors pathway together. This seminar would be led by female 11th and 12th graders in the pathway and focus on building community, mentorship, and future aspirations in mathematics-related fields while giving structure and space to have explicit conversations

about confidence, stress, pressure, grades, and other relevant psychological factors that impact attrition.

Acknowledging the limitations of this study, recommendations for future research were offered, including the ongoing collection and analysis of data during and after any policy change or intervention. Additionally, a focus on the intersectionality of race and gender and how it impacts attrition patterns in high school high honors mathematics pathways is a necessary continuation of this study. Overall, the results and findings of this study are significant and should inform how Crescent decides to address this documented inequity, as well as provide potential insight for other schools that are experiencing similar patterns of attrition. This study is simply the first step in making sustainable, effective change in this community which could have far-reaching impacts for these students.

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APPENDIX A

PATHWAY EXIT SURVEY

# Survey on Changing Math Classes

Thank you for completing this survey. We really appreciate that you are taking the time to explain your decision more. This survey in no way affects your grade, placement, or level change. We just want to learn more about why students switch classes so we can make changes to better support students.

---

The respondent's email (**null**) was recorded on submission of this form.

* Required

1. Email *

2. What class were you initially in? *

   *Mark only one oval.*

   - PIB Algebra 2/3
   - Elementary Functions / Calculus 1
   - AP Calculus BC
   - Calculus 2/3
   - IB Math HL
   - Other: ____________________

3. What class do you want to switch to? *

   *Mark only one oval.*

   - Advanced Algebra 2
   - Advanced Precalculus
   - AP Calculus AB
   - IB Math SL
   - Other: ____________________

4. How relevant were each of the following factors in your decision-making process? *

*Mark only one oval per row.*

| | Unimportant/ I did not consider this. | Slightly important | Moderately important | Significantly important | The most important |
|---|---|---|---|---|---|
| Balancing all my academic classes | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Balancing my extracurriculars | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Feeling like I didn't belong | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Afraid I'm not going to succeed | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Not feeling smart enough | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Feel uncomfortable asking for help | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Don't like my teacher | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| What class my friends are in | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Who my classmates are | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Not enough people like me in class | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |

5. Please be more specific about your decision-making process. Again, we really appreciate learning more. *

Questions 6 and 7 were the Mindset Quiz from Dweck (2006) found in Appendix B

8. What is your gender identity? *

9. What is your racial or ethnic identity? *

10. Would you be willing to talk more in a short in-person interview? ((Ms. Merg would be the interviewer and there would be gift card compensation if that makes a difference one way or the other)) *

*Mark only one oval.*

- ( ) Yes
- ( ) No

APPENDIX B

MINDSET QUIZ AND RUBRIC

## MINDSET QUIZ
## & SCORING SHEET

Please read each statement carefully and then indicate the extent to which you agree or disagree, and then give yourself the corresponding point value.

| Question | Strongly Agree | Agree | Mostly Agree | Mostly Disagree | Disagree | Strongly Disagree | My Score |
|---|---|---|---|---|---|---|---|
| You have a certain amount of intelligence, and you can't really do much to change it | 0 | 1 | 2 | 3 | 4 | 5 | |
| Your intelligence is something about you that you can't change very much | 0 | 1 | 2 | 3 | 4 | 5 | |
| No matter who you are, you can significantly change your intelligence level | 5 | 4 | 3 | 2 | 1 | 0 | |
| To be honest, you can't really change how intelligent you are | 0 | 1 | 2 | 3 | 4 | 5 | |
| You can always substantially change how intelligent you are | 5 | 4 | 3 | 2 | 1 | 0 | |
| You can learn new things, but you can't really change your basic intelligence | 0 | 1 | 2 | 3 | 4 | 5 | |
| No matter how much intelligence you have, you can always change it quite a bit | 5 | 4 | 3 | 2 | 1 | 0 | |
| You can change even your basic intelligence level considerably | 5 | 4 | 3 | 2 | 1 | 0 | |
| You have a certain amount of talent, and you can't really do much to change it | 0 | 1 | 2 | 3 | 4 | 5 | |
| Your talent in an area is something about you that you can't change very much | 0 | 1 | 2 | 3 | 4 | 5 | |
| No matter who you are, you can significantly change your level of talent | 5 | 4 | 3 | 2 | 1 | 0 | |
| To be honest, you can't really change how much talent you have | 0 | 1 | 2 | 3 | 4 | 5 | |
| You can always substantially change how much talent you have | 5 | 4 | 3 | 2 | 1 | 0 | |
| You can learn new things, but you can't really change your basic level of talent | 0 | 1 | 2 | 3 | 4 | 5 | |
| No matter how much talent you have, you can always change it quite a bit | 5 | 4 | 3 | 2 | 1 | 0 | |
| You can change even your basic level of talent considerably | 5 | 4 | 3 | 2 | 1 | 0 | |
| **Total Score** | | | | | | | |

The Mindset Quiz was developed by Dweck, Carol (2008). Mindset: The new psychology of success. Random House Digital, Inc.

# MINDSET QUIZ
# & SCORING SHEET

| Scoring | |
|---|---|
| Categorization | Points Value |
| Strong Growth Mindset | 61-80 points |
| Growth Mindset with some Fixed Ideas | 41-60 points |
| Fixed Mindset with some Growth Ideas | 21-40 points |
| Strong Fixed Mindset | 0-20 points |

The Mindset Quiz was developed by Dweck, Carol (2008). Mindset: The new psychology of success. Random House Digital, Inc.

# APPENDIX C

## INTERVIEW PROTOCOL

Date: Time: Place: Interviewer: Interviewee:

**Introduction:**

- Say thank you for being here
- Introduce myself
- Explain the purpose of the study
- Collect the signed consent form
- Talk about the general structure (# of questions, how long it'll take)

"Do you have any questions?"

**Opening questions:**
"Hey, how's your day been so far?"
"What's something you're looking forward to?"

**Interview questions:**

(1) If you had to write a "math autobiography" - what are some of the things that it would say?
(2) What does success look like for you in a math class?
(3) When did you start considering switching classes?
(4) If you had to make a pros and cons list for the decision - what are some of the things on each list?
(5) Did you talk to anyone when weighing your decision? Counselor, parent, friend? What did they say?
(6) Why did you decide to change classes

**Potential probes:**
"Tell me more."
"Could you explain?"
"What does that mean to you?

**Closing instructions:**

- Say thank you again
- Ask for any final questions
- Assure the interviewee of the confidentiality of the interview.
- Ask if I can follow up with another interview if needed
- Tell the interviewee how they'll see the results