“When Are We Going To Use This?” Understanding Student Math Achievement at the Secondary Level

Many people can imagine how they felt as a math student and especially when that experience was negative. People even confide in each other about how these experiences shaped them as budding mathematicians and how negative experiences deterred them from engaging and finding meaning. Such anecdotes begin in the primary through middle school years and can become ingrained in adult mindsets (Aguilar, 2021; Shabab, 2024; Luttenberger et al., 2018). An alarming two-thirds of American adults reported not only disliking math, but also specifically hating it (Aguilar, 2021; Furner, 2001). These stories serve as moments of camaraderie, uniting individuals scorned as victims of a common enemy. Mathematics has been increasingly viewed negatively, a perception continually reinforced by its perceived boring content, monotonous textbook problems, and difficult exams (Aguilar, 2021; Grootenboer & Marshman, 2016). Many of these experiences contribute not only to one's perception of math but also to one's self-perception as a student, leading them to categorize themselves as either good at math or not (Wigfield & Eccles, 2000).

Much of this perception stems from the belief that mathematical intelligence is fixed and cannot be improved through work or practice (Gonzalez-DeHass, 2024). However, mathematical intelligence is considered malleable rather than fixed, with only slightly less than half attributed to innate intelligence. The other half is attributed to perseverance and dedication (Bongers, 1999; Hickman & Sherman, 2019). This belief shapes assumptions about what it means to be smart and who belongs to the elite club of those considered inherently bright (Wigfield & Eccles, 2000). A significant contributor to this belief system is the alarmingly attributed decline in mathematics achievement and standardized test scores (National Center for Education Statistics, 2023; National Science Board, 2023).

The National Science Board (TNSB) highlighted declining math scores as a significant concern for students' overall academic achievement in the United States (2023). According to the TNSB, in a national mathematics assessment study (2022), there was "The largest decline in scores for 4th and 8th graders over the past 33 years" (p.1), demonstrating a genuine concern requiring a sufficient response. The National Center for Education Statistics (NCES) also discovered decreased mathematics test scores in their study (2023), where they reported significant drops in student math scores on the National Assessment of Educational Progress (NAEP). The NCES (2023) found that math test scores, primarily among adolescents, declined the most in the United States since 2019. This decline raises concerns about the future of STEM and economic growth, as STEM careers become more prevalent and professionals in these fields seek adults who can take risks and offer unique perspectives (Bongers, 1999). Test scores are among the most significant measures educators use to assess students' understanding, and these numbers are particularly relevant in a technological future where students need to be equipped for the task at hand (Grootenboer & Marshman, 2016).

Mathematics is essential for the skills it develops, such as problem-solving, making connections to one's life, and exploring potential career choices (Fielding & Makar, 2008). Fielding and Makar (2008) describe the mathematical sciences as an integral component of how different nations thrive as "they drive the data analysis, forecasting, modelling, decision-making, management, design and technological principles that underpin every sector of modern enterprise" (p. 1). However, international trends indicate that as demand for STEM skills increases, student involvement and engagement in STEM are decreasing (Fielding & Makar, 2008). As students transition from elementary to secondary school, they become progressively more disengaged from mathematics and, therefore, “switching off” (Collie et al., p. 1, 2018), leading to disinterest and limited focus (Fielding & Makar, 2008).

Disengagement and decreased motivation, which in turn affect mathematics test scores, are concerning, as STEM subjects are integral to potential career choices and contribute to societal advancement (Collie et al., 2018; Fielding & Makar, 2008; Grootenboer & Marshman, 2016). Many current students need to score proficiently on mathematics exams to prepare for STEM careers (The National Science Board, 2023). Although this is not the only measure of a child’s understanding, it offers insight into what may be driving this decline. As students enter a world where the need for technological skills grows, adapting to and integrating into it is becoming more crucial than ever (Grootenboer & Marshman, 2016). As technology advances rapidly, demand for analytical individuals with strong mathematical skills is expected to continue rising to meet current workforce needs (Grootenboer & Marshman, 2016).

Problem of Practice

Declining academic proficiency in mathematics is of concern as students transition from elementary to secondary school. Poor mathematical proficiency is often associated with high levels of math anxiety (MA), contributing to long-term disengagement and avoidance of mathematics, which arguably continues throughout people's lives (Luttenberger et al., 2018). Both the TNSB (2022) and the NCES (2023) reported that the United States is experiencing an unprecedented decline in math assessment scores among adolescents. As scores decline, so does students' perception of mathematics. This leaves students without a sense of belonging, leading to short-term consequences such as disengagement, disaffection, debilitating affect, and a poor sense of mathematical identity (Grootenboer & Marshman, 2016). However, short-term consequences often become long-term ones, leading students to disengage from mathematics courses and, consequently, from STEM careers (Grootenboer & Marshman, 2016). This matters because STEM careers are growing rapidly and offer both financial security and societal advancement (Collie et al., 2018; Fielding & Makar, 2008; Grootenboer & Marshman, 2016).

Ecological System Theory

The Ecological Systems Theory (EST), developed by Urie Bronfenbrenner (1979), is an ecological approach to examining problems at the systemic level. It uses the microsystem, mesosystem, exosystem, macrosystem, and chronosystem to explain how factors within each level affect one another, directly and indirectly. Each system exists within concentric circles that expand outward to demonstrate how systems interact with the individual, extend to society, and then, in the largest circle, to time. However, contributing factors are not always confined to a single system and may span two or more categories in the EST model.

Microsystem

The microsystem component of the ecological systems model focuses on a student's immediate environment. A child's immediate environment impacts them daily. Such interactions include a teacher's choice of instructional strategies, curriculum, their relationship with the student, and the overall classroom environment. This portion of the model considers a teacher's pedagogical decisions, which are based on their perceptions of mathematics. The microsystem also emphasizes the impact of a student's daily interactions with their parents. By including parents' perceptions of mathematics, this section argues that their experiences can significantly influence how a student engages with mathematics, which in turn affects academic achievement.

Mesosystem

The mesosystem portion of the ecological systems model examines how parts of the microsystem interact and how the microsystem and mesosystem work in tandem. The mesosystem's components are primarily focused on relationships within a school setting. Such elements include teacher-to-teacher relationships, teacher-counselor relationships, after-school activities, and tutoring. However, parental support and the teacher-student relationship are also essential factors to consider, as they are integral to a student’s academic advancement.

Exosystem

The exosystem portion of the ecological systems model addresses how parts of these systems indirectly affect a student’s academic achievement. The exosystem components include external factors, such as policymakers' decisions that indirectly affect students, teachers, and parents. Educational policies, such as district curriculum choices, state and local funding, school culture, and professional development, indirectly impact teachers, who in turn affect students and parents. This creates a loop that continually affects one interested party and moves in a circular motion. Parental flexibility is another exosystem component that indirectly influences students and teachers. A parent who can devote more time to their child may support overall academic achievement more than a parent who works multiple jobs or a single, time-consuming job.

Macrosystem

The macrosystem component of the ecological systems model examines how broader social contexts, including beliefs and values, influence a student’s educational trajectory. This system focuses on cultural values surrounding math and how students may face different expectations or pressures based on those values. One essential component of the macrosystem is gender, which has multiple cultural aspects that impact a student's academic achievement. Such cultural elements include how society views women in mathematics and which expectations are valued and which are not.

Chronosystem

The chronosystem portion of the ecological systems model discusses how changes over time affect a student's academic achievement. The timeline of effects can include direct events in a student's family life or historical events that affect a student, directly or indirectly. Familial components may include a student graduating to the next academic level, moving to a different school, or parents' job opportunities. Historical components may consist of technological advances, political movements, or educational reforms. Both familial and historical components significantly affect a student's academic achievement.

Contributing Factors

Declining math achievement is best understood by examining the many intersecting factors that impact it. Factors such as math anxiety, avoidance, eurocentrism, socioeconomic status, familial relations, teacher preparedness, and working memory do not work in isolation. Instead, they constantly interact with one another, shaping students' relationships, perceptions, and feelings toward math. The contributing factors of this paper were chosen in a deliberate order. The order was intended to help the reader understand how each factor builds upon the one that precedes it and how they are intertwined. Each factor is often understood as a separate color on a painter's palette. However, I encourage the reader to view these factors as a painting where the colors are mixed to evoke something more profound. As the painter, I hope the reader understands that a painting is best interpreted when the colors are blended on a canvas rather than existing in isolation.

Math Anxiety

Math anxiety is the broadest contributing factor, as it falls within the mesosystem of Bronfenbrenner's Ecological Systems Theory (1979) and interacts with each subsystem. MA directly impacts the individual, as seen in the microsystem through interactions with teachers, parents, and peers. Societal perceptions of mathematics (also within the microsystem) that perpetuate stereotypes about math reinforce MA through a cyclical relationship (Aguilar, 2021; Grootenboer & Marshman, 2016). MA also interacts with both the mesosystem and exosystem. Within the mesosystem, it affects parental support through resource allocation or involvement in their child's academic journey (Sirin, 2005; Reardon, 2011). In the exosystem, district curricular choices and teacher professional development often respond to existing student, teacher, and parent MA (Schaeffer et al., 2020; Hembree, 1990; Kelly & Tomhave, 1985).

Math anxiety (MA) is defined as "feelings of apprehension and increased physiological reactivity when individuals deal with math" (Luttenberger et al., 2018, p. 312). In their study, Luttenberger et al. (2018) found that almost all adults in the U.S. indicate that they experience math anxiety to *some* degree, where about a quarter of those adults express *severe* levels of MA. Feelings of MA often persist into adulthood, but they typically trace back to primary school, when students first experience them (Barroso et al., 2021). As students transition from elementary to secondary school, it marks a significant shift in their emotional state, resulting in a substantial increase in feelings of anxiety among adolescent students (Luttenberger et al., 2018; Sorvo et al., 2022). Feelings of MA peak as students transition from middle school to high school (Barroso et al., 2021), demonstrating a sustained increase in math anxiety throughout students' academic careers.

Academic-specific anxieties, which differ significantly from general anxiety, demonstrate a far greater negative impact on mathematical cognition, causing students at the secondary level to perform inadequately on tests and demonstrating poor academic achievement (Carey et al., 2017). Decreased cognition attributed to math anxiety is explained at a distinct physiological level, characterized by increased heart rates, sweaty palms, and confused thoughts, which can

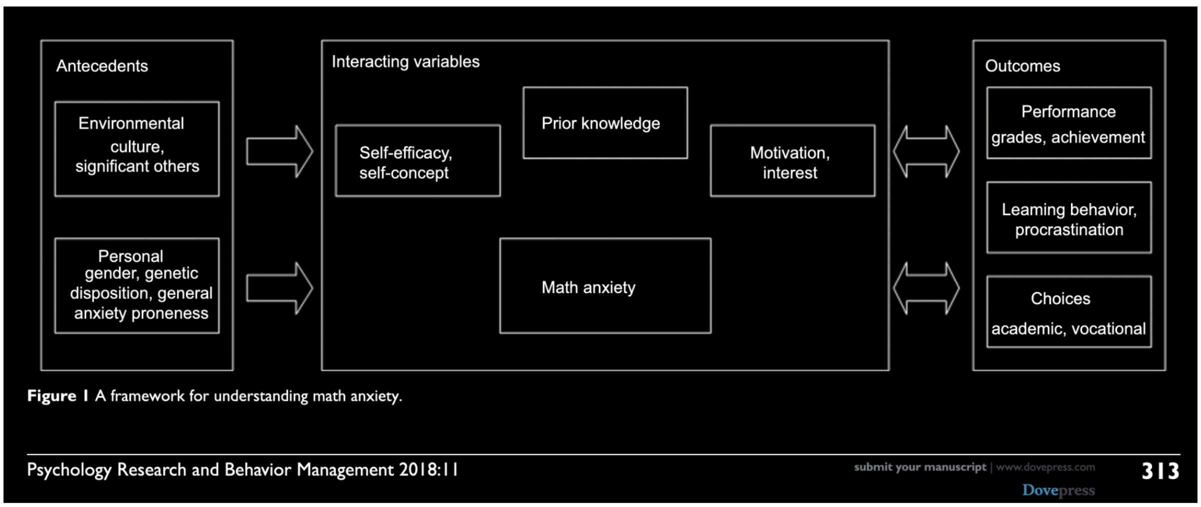

Figure 1 A framework for understanding math anxiety.

predict lower academic achievement than negative thoughts alone (Dowker et al., 2016). However, math anxiety and achievement are not separate entities; they work in tandem. The reciprocal theory helps explain a *cycle* between poor math achievement and MA (Sorvo et al., 2022), and the deficit theory (Carey et al., 2017) helps explain why students develop MA because of negative experiences with poor performance. Therefore, the reciprocity between anxiety and achievement underlines the profound implications of math anxiety on students' academic success (Barroso et al., 2021; Mohring et al., 2024). Math anxiety naturally leads to math avoidance, underscoring the urgent need to address this concern in students (Luttenberger et al., 2018).

Avoidance

High levels of math anxiety and subsequent avoidance of math lead to lower math achievement (Daker et al., 2021). In human survival, avoiding people, places, or things that could harm our existence protects us when the threat-to-risk ratio is unbalanced. However, when avoidance pervades academic settings, the long-term effect can be detrimental (Barroso et al., 2021). Math avoidance is hypothesized to emerge from a student's cost-benefit analysis in which anxiety does not outweigh the engagement required to perform specific math-related tasks (Choe et al., 2019). Shabab (2024) describes math avoidance as "the psychologically safeguarding impulse to disengage from mathematically demanding tasks that is brought about by fear of the threat of failure among students…" (p. 113). As explained previously, middle school is often the first time when students develop unfavorable and extreme crippling feelings toward math (Luttenberger et al., 2018; Sorvo et al., 2022), and Choe et al. (2019) explain how these fears morph into avoidance. Feelings of avoidance usually start around the same transitional period as math anxiety, leading to poor academic achievement (Grootenboer & Marshman, 2016; Sorvo et al., 2022). Students with math avoidance may unconsciously avoid math as they would other phobias to escape a perceived threat, which further perpetuates a cycle of anxiety, resulting in limited exposure to the curriculum, reduced practice, and lower levels of academic outcomes (Choe et al., 2019). Math anxiety not only leads to avoidance of mathematical tasks and lower achievement, but long-term avoidance also deters students from pursuing STEM-related courses in their academic trajectories (Choe et al., 2019; Kyttälä & Björn, 2022).

STEM Courses and Career Avoidance

The number of students deterred from higher-level math courses in school is causing a wide range of issues nationally and internationally (Grootenboer & Marshman, 2016). Evidence indicates that lower enrollment rates in secondary math courses are primarily observed in high school and extend to university-level classes (Daker et al., 2021). In their study, Daker et al. (2021) tracked students for four years throughout their college careers. They found that math anxiety was a primary factor in STEM course avoidance, even when controlling for differences in mathematical abilities (Daker et al., 2021). In his study, Ahmed (2018) also discovered that there was a positive association between students with high levels of math anxiety and math course avoidance. Students who exhibit MA tend to elect fewer math courses in secondary schools and avoid math-related situations entirely, which helps explain the drastic increase in math career avoidance (Luttenberger et al., 2018). Alarmingly low enrollment rates in STEM *courses* suggest that the long-term effects of MA deter students from entering STEM *professions* (Luttenberger et al., 2018). The troubling decline in enrollment in mathematics courses is particularly noticeable among those seeking STEM careers, where few applicants are prepared to fill these roles (Barroso et al., 2021).

High math anxiety deters students from enrolling in STEM courses, ultimately reducing their desire to pursue STEM careers (Eidlin-Levy et al., 2023). When math anxiety persists into the final years of college (when students are making career decisions), many intentionally avoid fields within math and other STEM-related specialties (Luttenberger et al., 2018). The reciprocal theory explains the cycle between math achievement and math anxiety, where they both work interchangeably with one another (Sorvo et al., 2022; Carey et al., 2017), and with heightened anxiety comes decreased math achievement, which is considered a crucial component when considering career choices (Barroso et al., 2021). Students who exhibit math anxiety are therefore less likely to consider STEM careers, which is a concern given the increasing demand for STEM professionals (Ahmed, 2018; Barroso et al., 2021). The more concerning statistic is that students are not the only individuals in the education space who have MA and therefore avoid mathematics; their teachers do as well (Luttenberger et al., 2018). Math anxiety among teachers leads them to avoid math, which in turn affects their students' achievement (Luttenberger et al., 2018).

Teacher Avoidance

Teachers exhibit significant levels of MA, regardless of whether math is their chosen specialty (Luttenberger et al., 2018). Early education teachers have the highest proportion of MA degrees among college majors, which can undermine students' beliefs (Schaeffer et al., 2020; Hembree, 1990; Kelly & Tomhave, 1985). Students are significantly influenced by their teachers' perceptions, approaches, and attitudes towards mathematics, creating a cycle of fear and avoidance (Luttenberger et al., 2018). Math anxiety and, consequently, avoidance are fostered in class and passed on to students if teachers perpetuate the stereotype that ability is fixed (Luttenberger et al., 2018). Believing that math is meant only for gifted children also leads teachers to expect less of certain students and, therefore, to refrain from challenging them to overcome psychological barriers. Teachers may also avoid math due to their MA by limiting instruction, avoiding complex problems, and focusing on standard algorithms/rote memorization (Hadley, 2011). These tendencies often fail to expose students to mathematical discourse and the critical thinking skills they need, leaving them inadequately prepared for future math courses and ultimately resulting in poor academic achievement (Ramirez et al., 2018).

Ralph Connelly, a professor at Brock University who teaches prospective teachers, has found that almost half of his students are not only fearful of mathematics themselves but also especially fearful of guiding their future students (Bongers, 1999). In their study, Schaeffer et al. (2020) found that teachers' math anxiety directly affected students' math achievement; the higher the teacher's MA, the less mathematical content their students were able to learn. Schaeffer et al. (2020) concluded that math-anxious teachers delivered less instruction than their less anxious colleagues and avoided cognitively demanding math activities. An imperative observation Schaeffer et al. (2020) uncovered is that "math anxious teachers may have fundamentally different attitudes about the importance of math and may expect less from their students in terms of math learning. These lower expectations of their students, either explicitly or implicitly, may influence their students' personal interest in and motivation around math" (p. 5). Teachers' apprehension towards mathematics instills fear in students, who become less willing to take risks and fully engage with their instruction. Teacher apprehension affects students, sustaining generations of math-anxious individuals (Schaeffer, 2021). Although teachers' attitudes significantly influence students' belief systems (Luttenberger et al., 2018), they are also influenced by their parents' attitudes (Maloney, 2015).

Familial Avoidance

Many family members are hesitant to help their children as they, too, have mathematics anxiety and have avoided math for a long time, which unintentionally instills these fears in their children (Casad et al., 2015). Math anxiety can begin as early as preschool, when parents feel apprehensive and avoid discussing numbers and incorporating everyday number sense into their children's daily activities (Berkowitz et al., 2021). Students who perceive their parents as uncomfortable and anxious around mathematics are at a higher risk of developing math anxiety (Maloney, 2015). A student who develops MA may be doing so because they internalize their parents' fears and, therefore, view mathematical ability as fixed, believing they are either good or bad at math (Gonzalez-DeHass et al., 2024). Overall, a child's development of MA is determined less by whether the parent already exhibits these feelings than by whether the child perceives them (Schaeffer et al., 2020). In a study on parent-child math anxiety, Casad et al. (2015) found that parental math anxiety predicted a significant portion of students' math educational outcomes, including self-efficacy, achievement, behaviors, and attitudes. Silver et al. (2021) also found a direct correlation between parental math anxiety/beliefs and students' math achievement. Therefore, a parent's level of MA impacts two of the most critical academic aspects of a child’s education: their attitudes towards mathematics and ultimate academic achievement (Becker et al., 2022; Simmons et al., 2024). As Bronfenbrenner (1979) explained, math anxiety does not exist in a vacuum but is significantly influenced by broader societal structures. Cultural structures, such as Eurocentrism, help explain how math has been taught historically and who is included in the conversation.

Eurocentrism

Eurocentrism exists within the macrosystem of Bronfenbrenner’s (1979) ecological systems model as it embodies the cultural and societal norms of mathematics curriculum and instruction. The macrosystem reflects how society views Western teaching ideologies as standard, normative, and socially acceptable (Battey & Leyva, 2016), further perpetuating the narrative that mathematics belongs to specific groups. Mathematics education in the United States is deeply rooted in a historically colonial and philosophically Eurocentric perspective (Biraimah et al., 2024). Historically, math instruction has placed students within hierarchies of who is deemed intelligent and who is not, typically based on race (Battey & Leyva, 2016). The Eurocentric metaphysical belief in mathematics is treated as a universal truth; however, this assumption is biased because it marginalizes other perspectives on how mathematics should be learned (Raju, 2013; Schubring, 2021). These metaphysical beliefs historically isolate specific racial minorities, as the curriculum is far removed from application and therefore reinforces structural and procedural methodologies (Anderson, 1990).

Battey and Leyva (2016) utilize whiteness to describe the Eurocentric frameworks within classrooms that have systematically disenfranchised students of color and found that “whiteness has a dual nature: privileging Whites and oppressing those outside the boundary of White” (p. 51). Such privileges for white students include tracking, ability grouping, positive teacher beliefs about their intelligence, and mathematical capacity (Martin et al., 2024). Conversely, minoritized students face obstacles of systemic racism, such as stereotypes, biases, and lower teacher expectations, which diminish their self-esteem and, in turn, academic achievement (Mamedova & Orosco, 2024; Martin et al., 2024). The Eurocentric curriculum continually reinforces colonial perspectives, perpetuating a vicious cycle of educational inequities and diminishing the legitimacy of minoritized students' mathematical abilities (Biraimah et al., 2024; Miles et al., 2019).

Students of color are often perceived as invisible in the content but hypervisible in the classroom, as few minorities appear in public spaces of mathematics (Battey & Leyva, 2016). Culturally relevant curricula and honoring students' backgrounds have been shown to foster academic achievement and positive attitudes toward mathematics (Mamedova & Orosco, 2024). Visnovska et al. (2025) describe this type of instruction as an alternative to colonial practices, incorporating students' cultures and identities into their learning experiences to foster mathematical legitimacy. Practices such as decolonization alternatives (Visnovska et al., 2025) and Ethnomathematics (D’Ambrosio, 1985) help students cultivate mathematical literacy by drawing on their own experiences and cultural backgrounds, ultimately resulting in higher academic achievement (Biraimah & Kurtz, 2024; Pratama & Yelken, 2024). Eurocentric curricula, however, are not the only cultural structure that impacts students' belief systems and sense of belonging, as gender stereotypes also have both short-term and long-term consequences for students' futures in STEM.

Gender Stereotypes

Gender stereotypes fall within the macrosystem of Bronfenbrenner's Ecological Systems Theory (1979), as they are rooted in cultural norms and societal beliefs. The macrosystem helps explain how ingrained norms and beliefs interweave within society and, in particular, shape the stereotype that boys are better at math than girls (Dweck, 2007, 2008; Gonzalez-DeHass et al., 2024). Such negative stereotypes have a detrimental long-term effect on girls' academic beliefs and their career outcomes (Lauermann et al., 2017). Girls are more likely to avoid STEM-related courses and, in turn, STEM careers, therefore perpetuating the stereotype that they are less capable of filling these roles (Kiefer & Sekaquaptewa, 2007).

Gender Stereotypes and Math Anxiety

Gender stereotypes of female students in STEM perpetuate a vicious cycle of math anxiety, leading to poor math achievement among women (Rossi et al., 2022). Acknowledging and understanding gender stereotypes in a mathematical context is crucial to girls' success (Wolff, 2021), as girls show aversion and implicit negativity toward mathematics as early as first grade, even when accounting for the absence of gender differences (Cvencek et al., 2021). As stereotypes persist, negative feelings and anxiety towards mathematics intensify (Jouini et al., 2018), with girls reporting having more experiences with MA than boys (Grootenboer & Marshman, 2016; Gonzalez-DeHass et al., 2024). In their study, Luttenberger et al. (2018) and

Barroso et al. (2021) found that gender bias impacts math anxiety significantly at the secondary level, where girls internalize gender stereotypes about their abilities and consider themselves less capable than boys. Much of this anxiety stems from the math gender stereotype, which posits that society perceives men as innately better at math than women, leading to fixed math mindsets, feelings of not belonging in mathematical spaces, and low self-efficacy (Dweck, 2007, 2008; Gonzalez-DeHass et al., 2024).

Gender Stereotypes and Expectancy Value Theory

Girls often internalize negative beliefs about their math capabilities, which can lead to disengagement and avoidance of the subject (Fong et al., 2021; Mayerhofer et al., 2024). Expectancy-Value Theory (EVT), developed by Eccles and Wigfield (2002), as illustrated in the table below, is defined as a student's expectations and values regarding academic success and how these factors influence educational choices (Fong et al., 2021). In their study, Eccles and Wigfield (2024) found that students' EVT is different based on gender and that girls are more likely to conform to their gender-role stereotypes, leading to various beliefs about their ability in

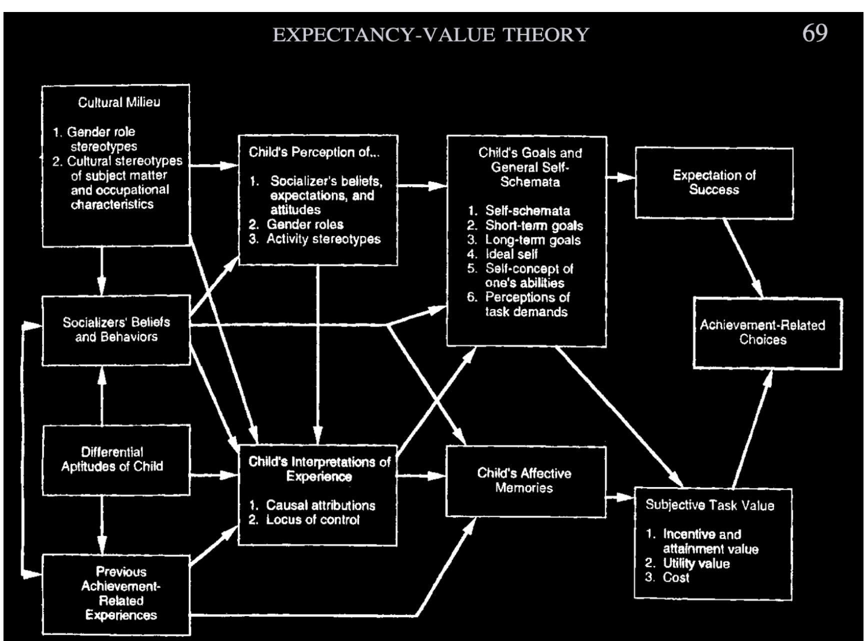

FIG. 1. Eccles, Wigfield, and colleagues' expectancy–value model of achievement motivation.

STEM. Self-efficacy is a component of EVT; students with higher self-efficacy are more likely to feel confident in their ability to succeed (Bohrnstedt et al., 2024; Eccles & Wigfield, 2002). Bohrnstedt et al. (2024) define self-efficacy as “a belief about one’s ability to carry out actions that lead to the attainment of a specified goal” (Bohrnstedt et al., 2024, p. 3), where self-efficacy is a predictor of student mathematics achievement (Stankov et al., 2012). Alarmingly, female students are less likely to have strong math attitudes and self-efficacy than their male peers, suggesting that math gender stereotypes negatively affect how female students see themselves (Dang, 2015).

Conversely, students who innately demonstrate self-efficacy are often better prepared for mathematical challenges and therefore have higher levels of motivation and engagement (Martin & Rimm-Kaufman, 2015, p. 360). Martin and Rimm-Kaufman (2015) found that “First, students with higher levels of math self-efficacy (relative to other students in their class) reported experiencing greater levels of emotional and social engagement in math class” (p. 369), suggesting that confidence in one's mathematical capabilities is a crucial indicator of student engagement. However, low self-efficacy, which has been found to affect girls more than boys, is associated with higher MA levels; as a result, girls are less engaged and perform worse in mathematics (Bohrnstedt et al., 2024; Schaeffer et al., 2020). Young girls’ mindsets and beliefs about mathematics constitute a gender-specific burden that affects their motivation, leading to lower math competence and achievement (Heyder et al., 2020). Watt et al. (2019) support this claim, finding that boys face lower social costs than girls (who perceive math mastery as riskier) and are therefore more willing to take risks and engage with complex content. Self-efficacy is crucial when considering female mindsets and beliefs, and it also plays a role in avoiding STEM courses and careers.

Gender Stereotypes and Career Avoidance

Math anxiety and achievement at the secondary level were found to be critical at specific educational transition points for girls, thereby influencing their avoidance of courses and potential career paths (Ma & Zu, 2004; Sorvo et al., 2022). Avoidance in math is attributed to perceived inadequacy and incompetence, as students with lower self-efficacy report feeling minimally engaged (Miller et al., 2021), and this perception directly correlates with STEM outcomes (Dang, 2015). A study by Wilson and Mack (2014), conducted from 2001 to 2013, found that negative attitudes towards mathematics had long-term effects, significantly influencing female enrollment in math classes, with participation rates dropping by more than 11%. Implicit math-gender stereotypes continue to be observed in elementary-level students and increase substantially at the secondary level, which predicts girls' achievement and desire to enroll in math courses (Steffens et al., 2010). Declining female enrollment in math classes creates a pipeline effect, in which they self-isolate from STEM careers, reinforcing gender disparities in STEM fields (Luttenberger et al., 2018).

Data show that women are more likely to avoid STEM careers than men due to the math gender stereotype and societal expectations (Lauermann et al., 2017). Gender stereotypes heavily influence women's math performance, which in turn affects their desire to pursue STEM careers (Kiefer & Sekaquaptewa, 2007). As previously discussed, math self-efficacy is a key determinant of student engagement and overall academic achievement. Students with positive experiences in math and higher self-efficacy are more likely to pursue STEM-related careers (Watt et al., 2019). Heyder et al. (2020) found that “female students’ fixed mindset in math was associated with not only a lower ability self-concept, but also with lower intrinsic motivation” (p.183), thereby explaining why females are less likely to pursue STEM careers. Lindner et al. (2022) concluded, "Therefore, to meet society's expectations, women may be more willing to accept less advantageous characteristics, such as being weak. For women in male-dominated STEM occupations, for example, research has proven that they have a "stigma consciousness", according to which they adjust their appearance and/or behavior to avoid negative judgment and stereotypes" (p. 18). The underrepresentation of women in STEM highlights the lasting impact of societal perceptions on women's mathematical abilities. These effects are especially concerning because STEM fields are among the highest-paying careers and often hold significant positions of power (Jouini et al., 2018).

Teacher Perception and Stereotypes

Female teachers who have experienced gender stereotypes themselves still exhibit anxiety, which is intuitively perceived by their female students (Beilock et al., 2010). It has been suggested that teachers' math anxiety negatively impacts female students' math achievement, as the students associate their teachers' aversion with broader societal beliefs, such as girls not being good at math (Beilock et al., 2010). Female students often look to their female teachers as role models; if they perceive their teachers as anxious, they may be less willing to engage in mathematics and develop the belief that math is only for boys (Schaeffer et al., 2020). Research by Casad et al. (2015) showed that girls with teachers who exhibited high math anxiety performed worse in math class and learned less of the curriculum by the end of the year than girls with teachers who had low or no math anxiety. Beilock et al. (2010) describe this as a transmission effect, in which female teachers' perceptions of girls in mathematics predict lower math achievement and increased math anxiety among their female students. Even teachers who do not teach math have expressed that boys are perceived as more competent in math by their parents and peers, reinforcing the stereotype that math is primarily intended for boys (Lindner et al., 2022). Teachers believed that boys were better suited for STEM fields because they perceived boys as having superior mathematical abilities and a greater interest in STEM careers than girls (Lindner et al., 2022). Teachers' attitudes and approaches strongly influence girls' beliefs about their math abilities and their eventual decline in math achievement (Luttenberger et al., 2018). Not only does teachers' transmission of gender stereotypes impact female students, but so do their parents' perceptions.

Familial Perception of Stereotypes

As discussed previously, familial math anxiety causes students to have a significant distrust in their capabilities and overall intelligence. However, how families interact and transmit gender stereotypes can also have the same detrimental effects (Casad et al., 2015). Bohrnstedt et al. (2024) explain the concept of a “lookingglass self” (p.3), which suggests that students see themselves through the perceptions of others, emphasizing the detrimental impact of math gender stereotypes on young girls. Luttenberger et al. (2018) and Vanbinst et al. (2020) both found that maternal perceptions had some of the most significant effects on female students. Families have been found to elicit the gender math stereotype, which significantly impacts the overall development of their female children's academic perception and performance. In their study, Eccles et al. (2024) found that “Parents provide their boy and girl children with different feedback regarding their math talents and performances (Eccles & Jacobs, 1986; Eccles-Parsons et al., 1982a; Jacobs & Eccles, 1986). For example, parents were more likely to attribute their son's math success to talent and their daughter's math success to hard work” (p.8). This supports Luttenberger et al.'s (2018) research, which claims that society views mathematical intelligence as both innate and fixed. Not only are gender stereotypes a cultural system that affects students' mathematical development, but socioeconomic status does as well, as it continues to divide and perpetuate systems of inequity and disparity.

Socioeconomic Status

Socioeconomic status (SES) exists primarily within the macrosystem of Bronfenbrenner's Ecological Systems Theory (1979). SES is a part of both societal and cultural structures, as it determines the types of schools children attend and their experiences with teachers. However, the broader implications of SES, such as familial access to resources and flexibility, also exist within the exosystem and are coupled with the macrosystem (Yamamoto & Holloway, 2010; Briley et al., 2014). Researchers have defined socioeconomic status in various ways, and it is an evolving concept that changes with society. Selvitopu and Kaya (2021) and Sirin (2005) both define students' SES in terms of their parents' education, income, and occupation. Sirin (2005) further explains the privileges associated with these attributes, including wealth, social status, and power. However, SES is not necessarily a combination of factors, but rather distinct factors, with "different socioeconomic measures are to be used as multiple separate variables" (Eriksson et al., 2021, p. 2). Sociologists and educational researchers who discuss SES often focus on parental income and its impact on student achievement (Coleman et al., 1966). However, SES is a broad umbrella term that encompasses many intersecting factors. Sirin (2005) supports this claim by stating, "Socioeconomic status is not only directly linked to academic achievement but also indirectly linked to it through multiple interacting systems, including students' racial and ethnic background, grade level, and school/neighborhood location" (p. 420). Other factors that contribute to poor academic achievement include low-income households, single-parent households, limited education, and attending underfunded schools (Sirin, 2005). This demonstrates that SES is a multifaceted system with interacting advantages and disadvantages for students (Selvitopu & Kaya, 2020). These complex, multidimensional SES factors can have detrimental long-term effects on students, hindering their academic potential.

Vulnerable populations, such as students with learning disabilities, are one of the many groups of children that are affected by the layered systems of SES. Children from low SES families are less likely than their high SES peers to develop academic proficiency in both math and reading, and are also more likely to develop a learning disability; however, more recent studies have been looking at why SES impacts academic proficiency (Demir et al., 2015; De Smedt et al., 2011). Demir et al. (2011) found that brain structure can be affected by attributes associated with low SES, thereby affecting student learning. The frontal, temporal, and hippocampal regions of the brain, which support verbal processing and executive functioning, are less active in students from low socioeconomic status (SES) backgrounds than in their high-SES peers (Demir et al., 2015). These brain regions also support mathematical reasoning and problem-solving (Demir et al., 2015). Verbal reasoning involves retrieving mathematical facts instantly, whereas visuospatial reasoning relies on visual models and physical manipulatives. In their study, De Smedt et al. (2011) found that children in grades 5-7 who scored lower in math were more likely to use visuospatial neural reasoning than their higher-achieving peers who used verbal neural reasoning. They are also more likely to rely on procedural strategies such as counting on their fingers, using number lines, and other manipulatives, not only later than their high-SES peers but also for longer (Demir et al., 2015). These learning differences occur so early that, with limited access to resources, children face an educational disadvantage (Rittle-Johnson et al., 2017; Sirin, 2005; Selvitopu & Kaya, 2020).

Although students from higher SES brackets demonstrate higher levels of academic achievement and fewer learning disabilities, particularly in mathematics (Demir et al., 2015;

Selvitopu & Kaya, 2020), it is crucial to understand that families in higher SES brackets do not produce innately intelligent children; instead, they have more readily available resources (Sirin, 2005; Reardon, 2011). Both education and income, which lead to additional resources, help predict students' achievement levels and explain the income achievement gap (Reardon, 2011; Selvitopu & Kaya, 2020; Sirin, 2005). Parental education used to be the most significant mitigating factor in a student's academic proficiency; however, familial income is now seen as equally crucial (Reardon, 2011). Parental education was a critical factor in student achievement because parents directly influence their students' academic outcomes. However, increasing income disparities among families have affected how families use income to access external resources to support their children (Reardon, 2011). For example, parents are now seeking external supports, such as tutors, curricular resources, and test-preparation programs, to help their children with their academic endeavors, thereby widening the gap between students from low- and high-SES backgrounds (Sirin, 2005; Selvitopu & Kaya, 2020). Although income and education are often seen as the primary factors contributing to higher student achievement, multiple *intersectional* factors within SES, including race and ethnicity, influence the income-achievement gap.

Understanding the academic achievement of different racial and ethnic groups is crucial as the United States becomes increasingly diverse demographically (Kao & Thompson, 2003). The National Center for Education Statistics (NCES) reported that only 10% of students from low-socioeconomic-status (SES) families scored in the top quartile on mathematics achievement. Of those students, only ⅓ in the middle quartile and 5% in the lowest quartile graduated from college (NCES, 2015). Low-income students are more likely to repeat grades and enroll in vocational programs, and less likely than their peers from higher socioeconomic status (SES) families to attend college (NCES, 2015; PISA, 2022). More specifically, students who enroll in these remedial and vocational classes tend to be minority students.

In contrast, their white peers enroll in more academically challenging courses, such as honors and AP classes (Kao & Thompson, 2003). However, much of this is beyond students' control, as more affluent, white, suburban schools are three times more likely to offer rigorous courses than low-income, minoritized, urban schools (Kao & Thompson, 2003). As academic achievement among minority students continues to decline, the scores of minority and white students from similar SES backgrounds are nearly identical, underscoring that the best predictors of academic achievement are parental income and education (Kao & Thompson).

Declining academic achievement in mathematics has been shown to predict a student's future academic success. Students from low-income families typically start school (as early as pre-school) with weaker mathematical knowledge (Rittle-Johnson et al., 2017; Roberts & Bryant, 2011; Duncan et al., 2007). Weaker mathematical expertise at such an early age, which predicts future success, is concerning, as students who demonstrate math proficiency tend to perform better in college, pursue more career aspirations, and achieve greater financial security (Rittle-Johnson et al., 2017). Parents with higher incomes can access additional resources to intervene and combat low math achievement, whereas those with lower incomes cannot (Reardon, 2011). However, both the income and achievement gaps have grown exponentially over the last few decades (Reardon, 2011; Selvitopu & Kaya, 2020), showing that socioeconomic disparities continue to disadvantage lower-income students relative to their more affluent peers.

Selvitopu & Kaya (2020) describe the pattern between SES and academic achievement through the sociological lens of the reproduction theory, “which is based on the assumption that the intergenerational reproduction of socioeconomic inequalities is strong and unchanging” (p.

8). Reardon (2011) warns that affluent students tend to do better in school and, therefore, are more likely to become wealthy, perpetuating a cycle of economic and social inequity (Selvitopu & Kaya, 2020). Declining math achievement does not happen suddenly; it happens gradually. Multiple factors contribute to declining math achievement, including socioeconomic status, particularly parental income and education levels. Higher income gives parents more resources to help their children overcome academic obstacles. However, income does not tell the whole story, as interconnected SES factors such as students' racial/ethnic background, grade level, school/neighborhood location, single-parent or less-educated students, and attendance at underfunded schools sustain inequity in mathematics proficiency (Sirin, 2005; Selvitopu & Kaya, 2020). Parent-related factors have also been linked to lower expectations for their children, contributing to declining academic achievement (Loughlin-Presnal & Bierman, 2017).

Fewer than half of parents with incomes below the poverty threshold expect their children to complete a bachelor's degree (Loughlin-Presnal & Bierman, 2017). However, diminished expectations are not necessarily attributed solely to income. Instead, these patterns are explained by parents' own parallel experiences as they were once students in underfunded schools with "limited access to high-quality schools and teachers" (Loughlin-Presnal & Bierman, 2017, p. 2), leading to fewer resources and therefore less social capital needed to invest in their child's academic achievement. As a result, parents who are products of inequitable academic institutions feel less equipped to help their children with homework, interact with teachers, and provide the resources necessary for their children's success (Yamamoto & Holloway, 2010; Briley et al., 2014). Structural socioeconomic inequality influences how families engage in their children's academic development, shaping both positive and negative expectations and levels of involvement.

Familial Relations

Familial relations, such as expectations and involvement, fall within the microsystem in Bronfenbrenner's (1979) ecological systems theory, as it is the level that directly interacts with students at the individual level. Familial relations encompass daily interactions, support, and belief systems that parents often hold for their children. However, familial relations can also be considered part of the mesosystem, as parents and teachers frequently interact in ways that affect student outcomes and extend beyond the individual level of the microsystem. Lastly, it can also exist within the exosystem, as expectations and involvement are typically tied to SES and access to resources. As explained earlier, each contributing factor does not always fall into a single category but often interacts across multiple concentric groupings.

Familial Expectations

Educational expectations between parents and students form a reciprocal relationship: parental expectations influence their child's academic achievement, and, in turn, the child's academic achievement influences the parents' expectations (Briley et al., 2014). Parental expectations are defined as "...realistic beliefs or judgments that parents have about their children's future achievement as reflected in course grades, highest level of schooling attained, or college attendance" (Yamamoto & Holloway, 2010, p. 191). Students who know their parents expect high academic achievement are more likely to strive for mathematical proficiency (Wang et al., 2021; Yamamoto & Holloway, 2010). Similarly, teachers' expectations also significantly affect student achievement, demonstrating the positive influence of both parents and teachers on students' GPAs, course selection, and attainment (Lee et al., 2025; Benner et al., 2021). In contrast, low teacher expectations are directly associated with lower academic achievement and a reduced likelihood of graduating from high school (Benner et al., 2021). Bioecological theory supports this notion by explaining that students' perceptions of their abilities directly reflect the mindsets and beliefs of those who closely influence their academic pursuits (Bronfenbrenner & Morris, 2006). Expectations precede children's attitudes, as research shows that parents with growth mindsets tend to raise students who develop skills such as autonomy and self-efficacy and who have overall positive dispositions toward math (Lee et al., 2025).

Students internalize these beliefs in both the short and long term (Yamamoto & Holloway, 2010). Parental expectations are directly tied to student expectations, even after accounting for previous academic achievement (Yamamoto & Holloway, 2010; Skaalvik & Skaalvik, 2011). Although high expectations can positively affect students' beliefs and mindsets, they can also have an inverse effect. Expectations without a perceived growth mindset in children can lead to educational anxiety and ultimately burnout (Xin & Yu, 2024). Therefore, parents who cultivate a culture of constant striving for perfection can perpetuate these obstacles, leading students to view mistakes as failures rather than learning opportunities (Xin & Yu, 2024). As students transition into adolescence, they become more susceptible to developing a fixed mindset in mathematics, which can lead to diminished confidence, increased math anxiety, and consequently, poor math achievement (Lee et al., 2025). Often, students view their intelligence as innate, which can discourage them when they do not meet parental expectations (Dweck & Yeager, 2019). However, parents who believe math ability can be acquired through practice are more likely to instill that mindset in their children (Lee et al., 2025). Parents with high academic expectations are also more likely to invest in their children's academic progress and get involved through volunteering, conferences, and at-home learning experiences (Loughlin-Presnal & Bierman, 2017). Among these parents, those who valued education more were more likely to become involved in their children's schooling, which, in turn, mediates their academic achievement (Yamamoto & Holloway, 2010; Xin & Yu, 2024).

Familial Involvement

Involvement affects student performance and overall achievement; however, its impact on student learning can be either beneficial or detrimental, depending on its quality and type (Wang & Wei, 2024). The Self-Determination Theory (SDT) examines how both positive and negative parental involvement can affect students' math performance (Wang & Wei, 2024). On the positive side, parents who promote autonomy-supportive practices increase the likelihood of students developing intrinsic motivation through open dialogue and collaboration (Joussemet et al., 2008; Feng et al., 2019; Wang & Wei, 2024). Conversely, overinvolvement can diminish autonomy and hinder students' motivation and ownership of their learning (Silinskas & Kikas, 2019; Wang & Wei, 2024; Xu et al., 2018). Parents and teachers can share this responsibility (Mendoza, 2009). Mendoza (2009) emphasizes the importance of having teachers who are willing to integrate families into learning opportunities alongside their children, thereby ensuring positive experiences with mathematics. However, children who perceive their families as overstepping into and controlling their academic pursuits are less likely to be mathematically proficient and more likely to develop negative beliefs about their abilities (Liu & Leighton, 2021; Wang & Wei, 2024). Therefore, more familial involvement does not necessarily lead to greater academic achievement (Wang & Wei, 2024).

As children grow and develop, so does their parental involvement, illustrating that involvement is a multifaceted process with numerous intersecting components (Degol et al., 2016). Degol et al. (2016) describe parental involvement as "not a static or uniform conceptualization but rather a dynamic, multidimensional process that is renegotiated as children mature" (p. 66). Early student achievement strongly influences future academic, social, and financial success, and negative parental involvement may jeopardize these outcomes (Liu & Leighton, 2021). Degol et al. (2016) explain that higher levels of involvement often determine college enrollment, with math achievement serving as a mediating factor through intergenerational transmissions of math ability. Intergenerational transmission of mathematical ability, however, may be a risk factor for math achievement, as math-anxious parents are more likely to instill these fears in their children through avoidance of complex tasks and negative beliefs about math (Maloney et al., 2015). However, familial relations are often mitigated by teachers' preparation and ability.

Teacher Preparedness

Teacher preparedness is a multifaceted and complex contributing factor, as its sub-factors exist within different levels of the Ecological Systems Theory (1979). Teacher credentialing sits within the exosystem, as students do not directly *experience* these programs but are indirectly *affected* by them. Professional development is also part of the exosystem, as it indirectly affects students, but it also exists within the macrosystem. The macrosystem helps explain societal and cultural norms and their impact on the microsystem, where professional development is often tailored to the current needs of both students and school districts. Teacher feedback and relationships, however, are the most direct interactions between teacher and student and therefore fall within the microsystem.

Teacher Credentialing

Teachers' knowledge of mathematics positively predicts students' achievement (Hill et al., 2005). Among the various teaching credentials, math is the most predictive of student success (Clotfelter et al., 2007, 2010), and teachers who complete the necessary courses for math licensure and demonstrate strong Mathematical Knowledge of Teaching (MKT) can help predict student performance and achievement (Clotfelter et al., 2010; Hill et al., 2018). Conversely, teachers who are not qualified to teach math and therefore have less mathematical knowledge help explain the achievement gap among disadvantaged students on the National Assessment of Educational Progress (Clotfelter et al., 2010; Hill et al., 2005; Shuls & Trivitt, 2015). Although proper credentialing is essential to student success, the quality and content of teacher credentialing programs matter more. Boyd et al. (2008) found that pre-service programs that focus primarily on what teachers will actually do in the classroom, rather than on abstract theoretical studies, produce more effective classroom teachers; however, most programs focus on the latter. Teacher experience also substantially affects student attainment, with less experienced teachers more likely to have students who perform poorly on state exams (Hill et al., 2018).

It is no surprise that more experienced teachers are more effective than those with less; however, Clotfelter et al. (2010) found that achievement levels nearly plateau after five years of experience, yielding mixed results on the impact of experience length. A problem in education is that highly qualified, more experienced teachers are often mismatched with the students they teach. Inexperienced teachers are frequently assigned to the highest-need students, while more experienced teachers are assigned to schools with students with less significant needs (Clotfelter et al., 2010). In their study, Hill et al. (2018) found that schools serving low-income, minority, and free/reduced-price lunch students are more likely to hire less qualified mathematics teachers than schools in the opposite categories. Their study reemphasizes that students most in need of highly qualified math educators often do not receive them, resulting in a significant achievement gap in mathematics (Clotfelter et al., 2010).

Professional Development

Professional development (PD) for teachers is often contentious, as educators and administrators struggle to find training that is both effective and actionable (Hill, 2009; Kennedy, 2016; Yoon et al., 2007). The goal of PD, particularly for math teachers, is for content-focused training to produce more knowledgeable teachers and improve students' academic achievement (Hill et al., 2005). However, educational researchers have debated what constitutes practical, actionable guidance for educators (Desimone & Garet, 2015; Hill, 2009; Garet et al., 2001; Yoon et al., 2007). In their study, Desimone and Garet (2015) argue that effective PD should integrate five key features: content focus, active learning, coherence, sustained duration, and collective participation. Content focus is what it sounds like: training that centers solely on the teacher's content specialty and the specific subject the student is learning. Active learning is a teaching approach in which teachers are integrated into the process and receive immediate feedback, rather than listening to a prolonged, often irrelevant lecture. Coherence is the interwoven set of goals among the school and all involved parties (teachers, parents, students, administrators, etc.). Sustained duration is an ongoing professional development experience throughout the year, rather than limited to a single day. Lastly, collective participation involves horizontal learning teams engaging in PD opportunities together. Desimone and Garet (2015) claim that professional development is less effective if it does not incorporate these five elements, particularly when hands-on, active learning is necessary.

However, they explain that it is not necessarily a clear path to implementing these elements into practical training. This may be because teachers adjust their pedagogical approaches in response to professional development, yet student outcomes still fail to meet state proficiency standards (Desimone & Garet, 2015; Hill, 2009). When professional development fails to improve student achievement, or when districts are underfunded, schools often revert to standard workshop training (Desimone & Garet, 2015). This creates a disconnect for teachers, who find professional development meaningless and uninformative for their instruction (Hill, 2009). More concerning, educators describe PD as "intellectually superficial" (Yoon et al., 2007, p. 1). This disconnect often stems from the fact that PD is usually held *outside* the classroom, while teachers are expected to implement new ideas *inside* the classroom, leaving educators at a crossroads about how to integrate this newly acquired knowledge with what they already know (Kennedy, 2016). Educational research is limited, as it predominantly emphasizes student outcomes and often overlooks the training needed to equip teachers effectively. Student achievement is successful only if the pertinent PD skills are well understood by the teacher and ultimately implemented in the classroom, which has been shown not to occur (Kennedy, 2016; Yoon et al., 2007). However, research shows that having some form of professional development is better than having none (Franklin & Chang, 2025; Gore et al., 2020; Park et al., 2025).

Gore et al. (2020) demonstrate the strengths of professional development, particularly quality teaching rounds (QTR), in enhancing children's academic achievement in math. They found that children showed a two-month increase in mathematical aptitude when teachers participated in a QTR, emphasizing the importance of PD that includes both active learning and collective participation (Desimone & Garet, 2015). Franklin and Chang (2025) also reported a significant increase in student math achievement when teachers participated in various PDs that focused on content knowledge. In contrast, colleagues who do not participate in content-specific PDs have students who do not demonstrate increased achievement (Park et al., 2025). However, educational researchers have found significant variation in teachers' responses to the same types of PD, resulting in differences in student outcomes (Desimone, 2015). Teachers come from schools with diverse demographics, learner characteristics, behaviors, and contexts, demonstrating that not all professional development is equally effective or leads to similarly high student achievement (Desimone, 2015).

Teacher Feedback and Relationships

Strong teacher-student relationships are integral to academic achievement, as they nurture a safe environment for students and foster rapport (Lewist et al., 2012). Wubbels et al. (2006) characterize positive teacher-student relationships as “a rather high degree of teacher influence and proximity towards students” (p. 25). Students who feel motivated and supported by their teachers tend to achieve higher academically, as they are encouraged to take risks and grapple with even the most challenging mathematical concepts (Lewis et al., 2012). Specifically, learner-centered relationship approaches to teaching, which encourage autonomy in learning, lead to higher levels of critical and creative thinking (Cornelius-White, 2007), a fundamental aspect of belief systems that promote self-efficacy (Hughes, 2011; Ryan & Patrick, 2001). Self-efficacy is especially important because it is typically linked to feelings of belonging and self-esteem, which, in turn, influence a child’s perception of their academic abilities (Hughes, 2011). These qualities foster classrooms in which adolescent students develop a positive relationship with school and are therefore more willing to engage and commit to their learning (Hafen et al., 2015; Hughes, 2011; Pianta et al., 2012; Ryan & Patrick, 2001). Developmental theory supports the notion that engaged and sensitive teachers, particularly those who teach adolescent students, recognize that relationships are crucial to the connection between learning and academic growth (Hafen et al., 2015). A foundational aspect of educational development is strong, positive teacher-to-student feedback (Kluger & DeNisi, 1996). Hattie and Timperley (2007) define feedback as “information provided to an agent (e.g., teacher, peer, book, parent, experience) regarding aspects of one's performance or understanding" (p. 102). Positive feedback increases a child's willingness to engage in cognitively demanding activities, leading to higher self-esteem and self-efficacy (Hattie & Timperley, 2007). Conversely, feedback that contradicts students' beliefs can harm academic outcomes and may undermine their self-perception (Hattie & Timperley, 2007). Although proper teacher preparation helps increase student academic achievement, cognitive barriers still play a significant role in a student's mathematical capabilities.

Working Memory

Working memory (WM) is also multifaceted within Ecological Systems Theory (1979), as it falls within multiple groupings. Working memory is primarily viewed as part of the microsystem, as it is directly related to students and their daily interactions. However, parent involvement and support for students' working memory skills fit best within the mesosystem, where home and school interact. In recent years, working memory (WM) has become a topic of interest among educational researchers, particularly regarding its impact on mathematics achievement (Blankenship et al., 2016; Sala & Gobet, 2017; Studer-Luethi et al., 2022). Working memory is a fundamental system of the brain's cognitive function, as it helps store, maintain, control, and manipulate information while simultaneously controlling attention (Blankenship et al., 2016; Giofrè et al., 2018; Medrano & Miller-Cotto, 2025; Söderqvist & Bergman Nutley, 2015; Studer-Luethi et al, 2022). Working memory (often confused with executive functioning (EF)) is a multifaceted short-term function that falls under the umbrella of EF. Executive functioning serves as the central control system for other cognitive processes (Studer-Luethi et al., 2022). Working memory often predicts academic achievement and future success, as students with weak WM processes are less likely to be academically proficient (Giofrè et al., 2018;

Söderqvist & Bergman Nutley, 2015). Working memory is an integral part of a young student's experience, as it helps organize academic tasks and enables more effective problem-solving (Medrano & Miller-Cotto, 2025; Studer-Luethi et al., 2022). Students with high working memory capacity are more willing to engage in simultaneous, cognitively demanding tasks, such as multi-step equations or abstract word problems (Ashcraft & Krause, 2007). This willingness fosters more opportunities to take on challenges and, in turn, leads to increased academic achievement (Giofrè et al., 2018; Studer-Luethi et al., 2022). Working memory, in particular, is a key factor in students' early mathematical success, beginning in the primary grades, where WM has repeatedly shown greater variance in ability than intelligence (Bull et al., 2008; Medrano & Miller-Cotto, 2024; Titz & Karbach, 2014). Visual-spatial skills are a specific component of WM that involves visual manipulations students use to compute distances between objects, such as numbers on a number line (Bull et al., 2008). These skills have been shown to strongly indicate children's early mathematical development, including counting, estimation, and subtraction (Bull et al., 2008; Medrano & Miller-Cotto, 2024; Titz & Karbach, 2014). The strength of using WM is that it allows students to retain relevant information, disregard irrelevant information, and focus on storing only what is necessary to solve the task at hand (Ashcraft & Krause, 2007). However, students who do not have a strong foundational WM capacity are more likely to struggle and therefore develop mathematical insecurities and anxiety (Suárez-Pellicioni et al., 2015). Math anxiety and WM work together in a "dual-task procedure" (Suárez-Pellicioni et al., 2015, p. 7) because the brain has difficulty differentiating priorities between anxious thoughts and the present mathematical task. However, MA and WM operate in a reciprocal cycle: students with higher MA have lower WM capacity, which in turn gives rise to lower MA (Suárez-Pellicioni et al., 2015; Titz & Karbach, 2014).

Conclusion

The research presented throughout this paper presents a compelling case that mathematics achievement is declining and that this decline can be attributed to a range of societal and cultural factors. Mathematics education is often a barrier for many students, and the pressure to excel or be mathematically proficient on standardized tests distracts from the systems that perpetuate unequal educational experiences. However, mathematics achievement is not solely an academic concern but, more importantly, an ethical one. The influences that impact students are integral to their success in life. Both positive and negative influences shape their self-esteem, not only their academic beliefs but also how they overcome obstacles, face challenges, and tackle the world's problems. How educators inspire and motivate students and help them develop autonomy and ownership of their learning matters more than ever, as rhetoric that suppresses the voices of ostracized students is increasingly the norm. The macrosystem factors, such as eurocentrism, gender stereotypes, socioeconomic barriers, and more, emphasize the exceedingly high disparities for marginalized students and the inaccessibility of high-quality and meaningful education. Inviting students to lead their own learning aims to heal the systemic structures that have silenced so many voices for too long. No child deserves to feel unwelcome, irrelevant, or anxious in any environment, let alone in a learning environment that should be equipping them with the tools to succeed.

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