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# ”How did I pass this and I didn’t know any of it?:” Reconsidering Social Cognitive Career Theory and the Development of Mathematical Self-Efficacy amid Structural Inequalities

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# “How did I pass this and I didn’t know any of it?:” A Critique of Social Cognitive Career Theory and the Development of Mathematical Self-Efficacy amid Structural Inequalities

## Introduction

(Paper type: ERM, Methods/Theory, research brief) This paper discusses the shortcomings of Social Cognitive Career Theory (SCCT), a commonly used theoretical framework [1], and proposes an alternative way to think about the role of self-efficacy in career choice development. The motivation of this paper was a quantitative study that produced results misaligned with SCCT and a follow-up qualitative study of the same population that used PVEST to explore underlying reasons. While empirical studies generally support the SCCT model (i.e., mathematics self-efficacy is correlated positively with mathematics performance [2]), research with minoritized youth is much less consistent [3], [4], [5], [6]. For example, Black students had higher mathematics self-efficacy compared to White, Hispanic, or Asian peers, but that did not translate to performance [7], [8]. Using PISA 2003 data, researchers even found a significant negative relationship between mathematics self-efficacy and achievement for Black students [9]. Together, these studies point to a puzzling relationship between self-efficacy, choice goals, performance, and other core features of SCCT.

The present research context is the Baltimore Online Algebra for Students in Technology (BOAST) program funded by the National Science Foundation (Grant No. DRL-2005790). The algebra-for-engineering program expands math learning time, opportunities to develop mastery and confidence in algebra, and exposure to engineering careers through a hybrid curriculum, role model videos, and field trips. A quasi-experimental mixed methods study of urban, mostly Black high school students in BOAST ($n$ = 89) revealed significant effects on STEM choice goals but not mathematics self-efficacy, STEM interest, or STEM outcome expectations comparing treatment and control groups [10]. Rather than concluding from these statistically insignificant findings that the intervention was unimpactful, the qualitative strand of the research—largely absent from SCCT research [6]—probes at limitations of SCCT when applied to pre-college, minoritized youth. In this paper, the authors critique SCCT based on qualitative findings from BOAST. The Phenomenological Variant of Ecological Systems Theory [11], [12] [6] provides clues for theoretical refinement of theories that better reflect diverse populations.

### *Social Cognitive Career Theory*

Social Cognitive Career Theory (SCCT) is a dominant and established theory [1], [13], [14] for explaining educational attainment outcomes and persistence in STEM. SCCT considers how person inputs (i.e., predisposition, gender, race/ethnicity) and contextual affordances shape learning experiences, which in turn influence self-efficacy and outcome expectations. SCCT assumes that stronger self-efficacy, outcome expectations, and personal goals contribute to higher interest, choice, and performance [15]. Self-efficacy—beliefs about one's ability to resolve new problems successfully in the future—determines what people believe is achievable with their abilities, encouraging performance goals that motivate efforts toward goal attainment. Numerous large-scale studies support the cohesive framework—at least partially. Indeed, meta-analyses have confirmed correlations between variables in the model [14], including a meta-analytic path analysis of diverse students in STEM domains [16].

In addition to explaining how career choices develop, SCCT is used to design and evaluate career planning interventions. In a recent systematic review of SCCT's application to

intervention studies [17], the model was used in 18 articles primarily in the United States. Across rural and urban settings, the interventions targeted self-efficacy. Self-efficacy[1] is the bedrock of the theory and a mainstay short-term outcome selected by education practitioners for evaluation.

While SCCT is widely used for explaining outcomes and designing interventions, numerous studies using nationally representative samples reported surprising findings surrounding self-efficacy in their models [3], [4], [5], [18]. For example, Zhang and colleagues (2021) found no significant relationship between mathematics self-efficacy and students' likelihood of choosing a STEM major in college [4]. While motivational theories [19], [20] and SCCT suggest that self-efficacy is the key construct for understanding who chooses STEM pathways or STEM majors, the authors found that self-efficacy showed no direct effect on choosing a STEM major when accounting for science and mathematics identity. The authors suggest that self-efficacy buttressed and supported STEM identity development [21]. This finding hints perhaps at identity as a construct omitted from SCCT (yet relevant for minoritized pre-college youth). Importantly, SCCT does not appear to explain how the role of self-efficacy differs in various learning contexts. Due to puzzling study conclusions and sparse qualitative research on SCCT [22], [23], SCCT is revisited in the current study through PVEST, a lens that highlights qualitative, inductive methods.

### *Phenomenological Variant of Ecological Systems Theory*

The Phenomenological Variant of Ecological Systems Theory (PVEST) [11], [12] centers adolescents' agency in shaping and determining both environment and behavior [24]. An *a priori* tenet of PVEST is that every human being presents some degree of vulnerability. Adolescents form situational identities in response to perceived risks (such as stereotypes and biases) and supports (such as parent advocates). The framework highlights potential paths leading to either resiliency or unproductive outcomes, given structural and cultural barriers [25], as well as supports, which have the potential to promote positive adaptive identities in spaces where youth have historically been unwelcomed or under-represented [11], [25].

For instance, Corneille et al. (2020) applied PVEST in their conceptual model: in the presence of structurally responsive education (i.e., access to STEM resources and courses, high-quality educators) and culturally responsive education (i.e., access to culturally relevant teaching, access to applications of STEM learning to impact community), students could develop supportive, protective factors (i.e., positive self-schemas) leading to increased participation of African American students in STEM fields [25]. Moreover, McGee, Spencer, and colleagues developed an understanding of the risk and protective factors of Black adolescents [26] and conceptualizations of mathematical identity [27] that disrupt problematic deficit-based narratives. These authors use PVEST to understand how environmental factors influence identity development and observed behavioral outcomes.

PVEST has typically been used for in-depth, small-scale qualitative research, whereas SCCT has been utilized for large-scale, cross-sectional studies; the two theories appear to speak different languages, holding incompatible axiological, epistemological, and ontological

[1] Mathematics self-efficacy is included in studies of STEM career pursuit, but not all SCCT models. Career self-efficacy is more typically involved in research based on Lent's SCCT.)

paradigms [28]. However, a handful of studies utilize PVEST merged with SCCT [29], unpack SCCT along qualitative methods [23], or analyze datasets through alternative theories including SCCT [30]. The empirical findings from BOAST, abbreviated for this research brief, indicate how PVEST and SCCT theories may be advanced if not integrated, particularly vis-à-vis understanding self-efficacy amid structural inequalities and the importance of STEM identity.

## Methods

Qualitative interviews sought to understand socio-environmental factors, postsecondary planning processes, and STEM career interests of primarily Black youth ($n$ = 25) from a large urban district in the BOAST algebra-for-engineering afterschool program between 2021 and 2024. The factors investigated, drawn from SCCT and PVEST, are presented in a conceptual framework (refer to Figure 1). The research question centered in this brief is "How do students describe mesosystem factors (STEM course quality, peer support, mentoring, family support) in relation to microsystem factors (STEM interest, STEM identity, math self-efficacy, and STEM choice goals)?" The mesosystem includes factors that have interconnected relationships with students, linking two or more settings containing the developing person, such as family background, mentorship opportunities, and peer groups setting [31]. Microsystem factors include those in the immediate setting [31], such as beliefs, skills, or strategies.

An initial deductive cycle of coding highlighted SCCT-derived constructs and a second inductive cycle used *in vivo* coding [32]. A codebook (Table 1) was used consistently across all transcripts. Codes were thematically analyzed [33] and factors visually illustrated [32] in a color-coded chart (Table 2) using student and school pseudonyms. Moreover, trends between high- versus low-persisting students in BOAST emerged. For this research brief, only two themes are highlighted: 1) High (vs. Realistic) Math Self-Efficacy and Opportunities to Learn and 2) Uneven Access—and Fully Aware.

## Results

### *Theme 1: High (vs. Realistic) Math Self-Efficacy and Opportunities to Learn*

This theme describes patterns between all mesosystem and microsystem codes (Table 2). Surprisingly, participants overall described high math self-efficacy, despite variable levels of mesosystem supports and self-reported math performance. Only three of 25 students reported low self-efficacy. Moreover, high-persistence students did not have the highest self-efficacy. Students with low-quality STEM courses reported high math self-efficacy, contrary to SCCT.

### *High-Quality STEM Courses*

High quality STEM courses are defined by hands-on, student-centered instruction that promotes cooperative learning and metacognitive skill development [34]. Students who had higher quality STEM courses tended to also have at least one teacher or counselor who offered more support with post-secondary planning; however, peer and family support for this subgroup was mixed. Counselor support appeared correlated with higher participation in STEM extracurricular activities, such as clubs and internships. Notably, support of peers and adults at

school supported the development of a consolidated STEM identity [35]. The opportunities to learn in high-quality STEM courses, coupled with STEM extracurricular activities and support from multiple teachers, reinforced *realistic* math self-efficacy. This self-estimation was associated with a STEM choice goal and higher persistence in BOAST (refer to Figure 2).

Flo is one student to illustrate this dynamic. Flo had no family in STEM, but her sister offered both pragmatic and emotional support. She described rich hands-on and relevant learning at school Zeta. She participated in a STEM internship at a local university and received straight As in math. Flo rated her math self-efficacy only as a seven out of ten and explained: "Because sometimes I don't know it, but I try to write down everything that the problem does say, and I just try to think what previous knowledge, what I do know, and I try to go from there." Flo articulated metacognitive insight of her learning [36] and engineering career goals.

### *Low-Quality STEM Courses*

Some students with high self-efficacy who had low-quality STEM courses, such as Marcus, Sylvia, and Maisie, did not develop consolidated STEM identities. These students had mostly absent (or even negative) peer influences and largely absent relationships with teachers or counselors at school. Family support for this subgroup was mixed; most referred to vague support (emotional or spiritual) from mothers, but few received pragmatic support such as college visits, support with applications, etc. For this group, their STEM identities were not consolidated. Math self-efficacy was high and seemed largely defined by the grade they received, but in the absence of continued opportunities to learn and develop more nuanced metacognitive understanding of themselves as learners [36], their postsecondary goals were largely vague and their persistence in BOAST petered out.

Maisie's story underscores this dynamic. Maisie described uninspiring learning in math and science courses. Regarding math, she said "they're all easy... I pass them with easy As." For science, she described "we didn't do anything" in ninth grade biology and chemistry, and not taking any science courses in tenth grade. Yet, she self-reported her confidence in math as a ten. Regarding mesosystem supports, she actively distrusts the adults at school, has minimal emotional support from peers, but emotional support from her mother. Like Maisie, Marcus and Sylvia rated themselves very high in their math confidence, while describing the weak school-based experiences in which they were evaluated. Sylvia noted, "I don't even get instructions, honestly… I'm usually just letting them answer it and then I get the answers," yet she rated her mathematics confidence as "eight out of ten." These students had unconsolidated STEM identities, limited persistence with the BOAST program, and ambivalent feelings about continued postsecondary education to pursue STEM-related jobs (such as radiology or ultrasound technician). They proclaimed high confidence but did not demonstrate metacognitive insight or awareness of how skills and capabilities could be used in the workforce.

Through the lens of PVEST [11], elevated mathematics self-efficacy may be a coping process in reaction to perceived discrimination, structural inequities, and an absence of culturally responsive education [25], leading to inflated but unrealistic math self-efficacy. *Elevated* refers to the gap between professed self-efficacy and documented proficiency or actual performance.

Ultimately, this maladaptive process did not buoy performance and meta-cognitive insight [36] but instead contributed to STEM attrition.

### *Theme 2: Uneven Access—and Fully Aware*

Student experiences revealed heterogeneity across the district, but students with higher-quality instruction clustered at specific schools. Students at Schools Beta and Zeta reported hands-on, project-based learning. Instructors checked for understanding, made sure it was contextualized to real world applications rather than purely theoretical, and the learning progressed in difficulty. They *did* science, rather than learning *about* science.

Students from Omega diverged from students at Beta and Zeta in their accounting of curricula and access to quality teachers. Shamya in particular aired grievances:

> I used to enjoy math, but once COVID started, I guess, me being at home for three years… It really knocked me off of really being a good student in math… And then algebra, they gave me a 60. So, I was like, 'How did I pass this and I didn't know any of it?' A lot of students was like, they passed. I'm like, 'Y'all, how did we all just pass this with no teacher?' Nobody had answers, they was just like, 'We don't know.' And I was just like, 'Okay, I'm not going to say nothing.'

Shamya reflected full awareness of being shepherded through the system, with little accountability for understanding content. Since peers did not seem eager to highlight this failure, she indicated complacency and later admonishment of her school administration. Students were aware that they could make it through high school without proficiency; while most students acquiesced to this system focused on herding students to graduation, students like Shamya urgently desired more support and investment. She attempted to channel her agency and found the responses unsatisfactory. This theme highlights the student awareness of structural inequalities yet limited mechanisms to advocate for change.

## Discussion

There is mounting evidence that the implicit assumptions underlying SCCT—that self-efficacy is the antecedent of outcome expectations, interests, goals, and actions, that confidence and competence are directly proportional—are insufficient, particularly with minoritized youth. Under some circumstances, students can develop a sense of self-efficacy that is not aligned with their actual proficiency. Those circumstances include distrust of adults in the school, awareness of low-quality instruction, and lack of access to high-quality STEM courses. In this study, overinflated mathematics self-efficacy has negative repercussions. While intuitively *low* self-efficacy does not support persistence in STEM, prior research has found that high mathematics self-efficacy (measured in high school) was associated with enrollment in a four-year institution for young Black women; however, this mathematics self-efficacy eroded over time and was associated with attrition [37]. While educators may want to grow students' confidence, grade inflation or passing students through the K-12 pipeline produces unintended consequences in the long-term. The authors warn educators of promoting elevated self-efficacy based upon false

mastery experiences and urge policymakers to focus on improving both access to high-quality instruction and gatekeepers of STEM opportunities (i.e., counselors, advisors, mentors).

Regarding theoretical advancement to encompass the experiences and structural inequalities shaping U.S. minoritized youths' career development, the puzzling literature and present study point to future directions. First, STEM identity ought to be included in models. Both this and prior studies have shown how science identity influences minoritized students' intention to pursue a STEM career [4], [35], [38]. Indeed, in a large scale-study using propensity score matching and applying alternative theories simultaneously, Stets and colleagues evaluated how holding a science identity in high school directly links to obtaining a science occupation [21]. The comparative approach showed that science identity formulated in K-12 educational systems uniquely increases the likelihood of URM students pursuing science occupations. Rather than self-efficacy, STEM identity—particularly mathematics identity [27]—may be a better construct for understanding minoritized youth's pursuit of engineering careers. As evidenced in this study, in uninspiring education settings focused on compliance (grades), students may employ high self-efficacy as a protective mechanism. Alternatively, math proficiency (operationalized as mastery, not grade) may add value to career choice development models.

Second, as advocated by Lent and co-authors of SCCT, a growing body of research in model-testing studies should be synthesized in a way to test applicability across gender, race/ethnicity, and their intersections, to assess whether the theory is equally or differentially useful in explaining career development of minoritized communities [16]. These authors have acknowledged that their analyses flatten all variability of racial groups into one category, and these demographic descriptors do not capture experiences (i.e., cultural values, socialization, bias) that may be linked to social identities. The relative limitations of PVEST and SCCT may benefit from mixed methods development [28], [39]; PVEST would benefit from quantitative methodological advancement, while SCCT would benefit from qualitative approaches. Recent scholarship moves the educational psychology field forward, employing Critical Race Mixed Methodology [39], [40] and PVEST as a guiding framework for anti-racist instrument development of a Multidimensional African American STEM Identity Instrument [41].

Lastly, future research ought to investigate how minoritized youth source self-efficacy. Lent and colleagues (2017) introduced the social cognitive model of career self-management to explain processes through which people contribute to their own educational and career trajectories, focused on process rather than content aspects of career development [42]. In this work, the authors note an important gap in the literature involves theoretical antecedents of self-efficacy and outcome expectations.

## Conclusion

SCCT continues to inform interventions and education research, yet the adequacy for minoritized youth has not sufficiently been determined. While SCCT posits that STEM interest arises from self-efficacy and outcome expectations, a growing body of literature along with this study introduce skepticism about the adequacy of the theory. The present study frames warnings around mathematics self-efficacy and STEM identity in the context of structural inequalities, pointing to directions for future research for both SCCT and PVEST.

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**Tables**

**Table 1: Codebook Ranking Schema for Mesosystem and Microsystem Factors**

| Construct | Low (red) | Medium (yellow) | High (green) |
|---|---|---|---|
| STEM Course Quality | Student describes limited access to math or science classes, absent teachers, or poor instruction | Student describes math or science classes in a neutral manner | Student describes math or science classes as rigorous, hands-on, engaging, relevant, etc. |
| Peer Support | Peer support absent or negative influence on student | Peer support limited, primarily to emotional support | Peer influence includes pragmatic, emotional, and/or academic support |
| Mentorship Opportunities | No adult at school with whom student discusses post-secondary plans | One adult at school identified who discusses post-secondary plans or provides support | One or multiple adults who discuss post-secondary plans and provide emotional, psychosocial, and/or academic encouragement into STEM pathways |
| Family Support | No family member with whom student discusses future plans | Family member(s) provide emotional support | Family member(s) provide various types of support (emotional, spiritual, pragmatic, etc.) |
| Math Self-Efficacy | Rating 0-3, or narrative description indicates no/low confidence | Rating 4-6, or narrative description indicates some confidence in some math classes | Rating 7-10, or narrative description indicates confidence in all math classes |
| STEM Interest | Limited passion or interest in science or math content | Some interest, describes STEM content that intrigues or excites | Exuberant interest, describes STEM content that thrills and excites |

| | | | |
|---|---|---|---|
| STEM Identity | Limited STEM identity; student does not describe affiliation with STEM ("science-type") people | STEM identity is split across communities of practice at home, school, and extracurricular activities; student describes some affiliation with STEM people | STEM identity is consolidated across communities of practice at home, school, and extracurricular activities; student describes strong affiliation with STEM people |
| STEM Choice Goals | Non-STEM career goal | N/A | STEM-aligned career goal identified |
| STEM Persistence | Completes limited or no work (at the time asked), though may attend field trip and watch role model videos | Completes some work (multiple modules, but not all, at the time asked), and may attend field trip/watch role model videos | Completes all work (all modules, at the time asked), including field trips and watching role model videos |

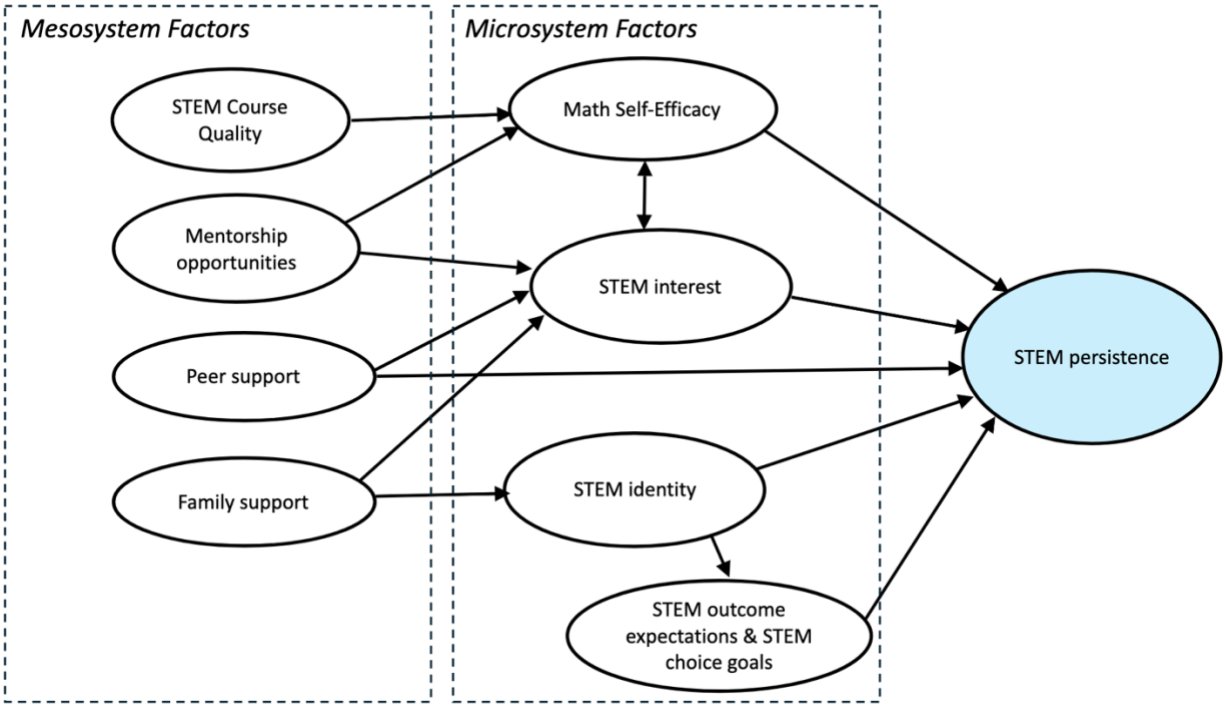
**Table 2: Matrix of Student Participants, Ratings for Mesosystem and Microsystem Factors**

| Participants | | Mesosystem Factors | | | | Microsystem Factors | | | | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Student | School | STEM Course Quality | Peer support | Mentoring, Advising, Counseling | Family Support | STEM interest | STEM identity | Math Self-efficacy | STEM Choice Goal | BOAST Persistence |
| Giovanni | Beta | | | | | | | | | |
| Janiyah | Zeta | | | | | | | | | |
| Flo | Zeta | | | | | | | | | |
| Trinity | Zeta | | | | | | | | | |
| Halle | Delta | | | | | | | | | |
| Damario | Kappa | | | | | | | | | |
| Nayeli | Lambda | | | | | | | | | |
| Leon | Delta | | | | | | | | | |
| Maisie | Omega | | | | | | | | | |
| Kyra | Alpha | | | | | | | | | |
| Raphael | Beta | | | | | | | | | |
| Mavis | Epsilon | | | | | | | | | |
| Avon | Kappa | | | | | | | | | |
| Macie | Delta | | | | | | | | | |
| Daniel | Kappa | | | | | | | | | |
| Aurora | Omega | | | | | | | | | |
| Zara | Zeta | | | | | | | | | |
| Gabriella | Alpha | | | | | | | | | |
| Kamilah | Gamma | | | | | | | | | |
| Marcus | Gamma | | | | | | | | | |
| Shamya | Omega | | | | | | | | | |
| Sylvia | Omega | | | | | | | | | |
| Lennon | Beta | | | | | | | | | |
| Ailani | Beta | | | | | | | | | |
| Jordan | Epsilon | | | | | | | | | |

*Note:* Each row represents a student participant in the study. School and student pseudonyms are used to preserve anonymity. Data is organized by self-reported persistence in the BOAST program (Green = high, Yellow = medium, Red = low). More specifically, from left to right, data is organized by mesosystem factors, microsystem factors, and persistence, as presented in the conceptual framework in Chapter 2. Empty cells indicate missing data.

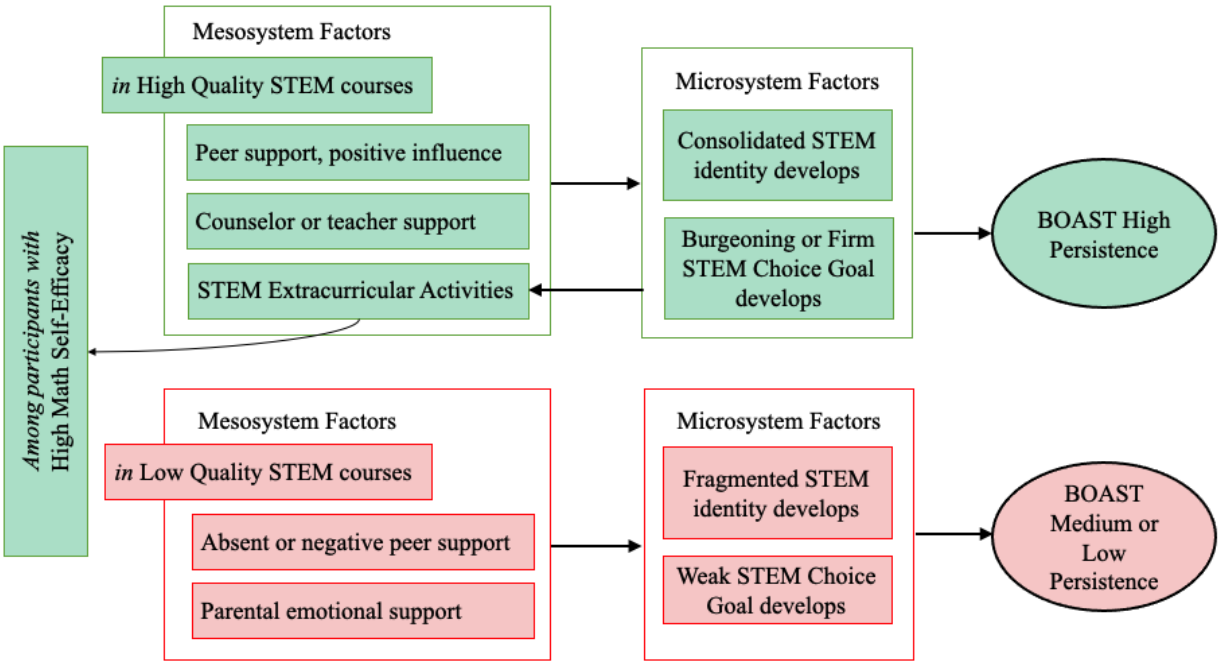
## Figures

**Figure 1: Conceptual Framework**




*Note*. Arrows indicate relationships supported by literature. In this research brief, the relationship between mesosystem factors and microsystem factors (but not STEM persistence) are discussed.

**Figure 2: Trends for Students with High Math Self-Efficacy**




*Note*. Based on empirical trends, the theorized process by which students with high quality STEM courses develop realistic math self-efficacy in a feedback loop (green). This feedback loop is contrasted with students with low quality STEM courses, who do not experience authentic opportunities to learn and trend towards low persistence in BOAST (red).