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Mind Over Matter: Is Entering STEM Dependent on Self-Perceptions? A Pedagogical Review

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ABSTRACT

By 2032, STEM occupations are expected to increase by 10.8% while non-STEM occupations are projected to increase only by 2.3%. However, STEM recruiters and employers struggle to adequately fill STEM positions and retain employees, despite workforce availability, leading to a gap in the STEM workforce. This gap has been exacerbated by a plethora of issues such as: student self-perceptions (science identity, self-efficacy, and sense of belonging), systemic biases, and a lack of career readiness. Social Cognitive Career Theory (SCCT) suggests ones' career choices come from interactions between multiple elements, including environmental, behavioral, and personal factors, and provides a valuable lens to dissect parameters that contribute to filling the STEM workforce gap. By adopting the SCCT framework to examine these factors, helpful remedies can be discovered like implementing undergraduate research experiences and active learning curriculum. In this thesis we explore the recent literature addressing the underlying causes, symptoms, and potential remediations of these disparities by examining the current pedagogical approaches in postsecondary education, with special attention to STEM engagement, retention, and career intent, to forecast students' behavior in relation to pursuing STEM related careers.

KEY WORDS: STEM, self-efficacy, science identity, sense of belonging, science competency, self-perceptions, career intent, career persistence, career awareness, and career readiness.

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AUTHOR NOTES

Dear reader, while drafting this manuscript I learned an exceedingly large amount of information about the field, our education system, and myself as a student and employee, which has drastically shaped my worldview, so I hope it can do the same for you.

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INTRODUCTION

By 2032, demand for Science, Technology, Engineering, and Math (STEM) occupations are expected to increase by 10.8%, compared to a 2.3% increase in demand for non-STEM occupations (Bureau of Labor Statistics, 2022). As reported by the NSF, women and minorities (African Americans and Hispanics) are both underrepresented in the STEM workforce relative to their presence in the workforce overall; women comprise 33% of the STEM workforce and 48% of the overall workforce, and minorities comprise 24% and 38%, respectively (National Science Foundation, 2023). Underrepresented groups experience barriers to retention in both academic and occupational settings due several factors, including a lower sense of belonging (SOB), reduced self-efficacy (SE), and lowered science identity (SI): simply put, these individuals do not feel like they fit in to their environment and lack support and representation in their field (Brainard & Carlin, 1998; Clark et al., 2016; Rainey et al., 2019; Sax et al., 2018). The National Science Foundation reports an increase of these minoritized groups in STEM fields since 2011, *e.g.* Hispanic STEM workers increased from 3.1 million to 5.1 million between 2011 and 2021 and Black or African American STEM workers increased from 2 million to 3 million in the same period, demonstrating the progress made so far towards addressing inequalities within STEM, but there is still more work to be done (National Science Foundation, 2023). Despite a growing STEM workforce, recruiters and employers struggle to adequately fill STEM positions and retain employees, citing a disconnect between employer requirements and employee training, particularly in soft skills (Newell & Ulrich, 2022; Prinsley & Baranyai, 2015). Analyzing recorded statistics about STEM domains provides useful quantitative data to pinpoint gaps and areas of improvement within the STEM education-to-career pipeline.

Between 2011 and 2021, women earned half of the awarded STEM bachelor's degrees overall (National Science Foundation, 2023), however disparities arise among specific STEM disciplines. Comparing earned bachelor's degrees among STEM fields, women comprised of 64% of earned degrees in biological and agricultural sciences, 66% of earned degrees in social and behavioral sciences, and 53% of chemistry degrees (National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023). Conversely, women only accounted for about a quarter of earned bachelor's degrees in engineering (24%), mathematics and computer sciences (26%), and physics (24%) respectively (National Center for Science and Engineering Statistics, 2023). Once employed, women in life sciences are less likely to be in tenure-track positions and have higher rates of leaving the field altogether (National Center for Science and Engineering Statistics, 2023), and this pattern is repeated in other STEM fields (Clark et al., 2016). One potential reason for women leaving STEM fields is reduced SOB due to feelings of a hostile environment in STEM, which has commonly been reported by women and minorities (Brainard & Carlin, 1998; Clark et al., 2016; Rainey et al., 2019; Sax et al., 2018; Williams & George, 2014).

Moreover, in 2020, only 26% of STEM bachelor degrees earned were from those in underrepresented minoritized groups: Black, Hispanic, American Indian, and Alaska Native students, but this group accounts for most associate degrees awarded in 2020, with 58% of minorities earning associates degrees. Alternatively, White and Asian students account for 70% of STEM bachelor's degrees awarded in 2020. Looking further in the future, the trend continues as the NSF reports that White and Asian students account for 81% of STEM doctoral degrees (Table 1).

Table 1. Science and Engineering Degree Recipients organized by race and degree level for 2020. Adapted from figure 7-4 in NSF23-315 (National Center for Science and Engineering Statistics, 2023). Percent representation of various racial and ethnic groups in the overall population and in degrees received.

	White	**Asian**	**Hispanic or Latino**	**Black or African American**	**American Indian or Alaska Native**	**Other**
US Population (18-34 years) (%)	54%	6%	22%	14%	0.9%	3%
Associate's Degree Recipients (%)	42%	10%	32%	10%	0.9%	5%
Bachelor's Degree Recipients (%)	58%	12%	17%	9%	0.4%	5%
Master's Degree Recipients (%)	60%	12%	13%	11%	0.4%	4%
Doctoral Degree Recipients (%)	70%	11%	9%	9%	0.4%	4%

Minority students are at the highest risk of leaving the STEM field during their undergraduate education, including changing their major and not graduating (Merolla et al., 2012; Stets et al., 2017). Similarly to women, evidence suggests this may be due to inadequate SOB feelings (e.g. not having a social network to other STEM students with similar backgrounds) (Merolla et al., 2012; Stets et al., 2017). Lastly, women historically are underrepresented in STEM graduate programs and make up less of the workforce with 35% for women and 65% for men respectively (National Center for Science and Engineering Statistics, 2023).

Gender disparities in the workforce are not limited to non-academic positions: a meta-analysis of 36 million authorships from over 100 countries between 2003 and 2018 quantified a gender gap in authorships in STEM domains (Holman et al., 2018). While some STEM domains, such as nursing, midwifery, and palliative care, are roughly equivalent in authorship between men and women, other domains like physics, computer science, and surgery subspecialities demonstrated significant underrepresentation of women (Holman et al., 2018).

Disparities in STEM representation among women and minoritized populations occur at all levels, including undergraduate education and degree conferral, pursuit of post-baccalaureate education and terminal degrees, workforce representation and advancement, and even academic publications (Brainard & Carlin, 1998; Estrada et al., 2016; Good et al., 2012; Holman et al., 2018; Merolla et al., 2012; National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023). This underrepresentation, along with entrenched practices and programs in higher education and the workforce, fuel disparities in the sense of belonging, science identity, and self-efficacy of underrepresented groups, which then leads to attrition and further exacerbates these groups' lack of representation (Estrada et al., 2016; Kricorian et al., 2020; Kuchynka et al., 2019; Kuchynka et al., 2021; Rainey et al., 2018; Theobald et al., 2020).

In this thesis, we explore the recent literature addressing the underlying causes, symptoms, and potential remediations of these disparities by examining the current pedagogical approaches in postsecondary education, with special attention to STEM engagement, retention, and career intent, to forecast students' behavior in relation to pursing STEM related careers. Additionally, by exploring the literature on SE, SOB, SI, science competency, self-perceptions, career awareness, career readiness, and career goal measures, this review can broaden our comprehension of STEM pursual and attrition.

THEORETICAL FRAMEWORKS SURROUNDING STEM RETENTION

Women, people of color, and women of color have historically been underrepresented in STEM, leading to a lack of intersectionality between social groups in STEM spaces (Kricorian et al., 2020; National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023; Ong et al., 2018). Attrition from STEM fields occurs across all levels – from undergraduate to established career professional, and is precipitated by factors such as decreased SOB, SI, and SE, lack of advancement or recognition, and a wide variety of life factors, among other things (Hernandez et al., 2018; Lent et al., 1994; Liu et al., 2019; Rainey et al., 2019; Tan-Wilson et al., 2020). STEM attrition at the undergraduate level has been the subject of vigorous research for decades, and several theoretical frameworks have been introduced that are useful in examining this issue.

One such framework is Self-Efficacy, which Albert Bandura defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances (Bandura, 1977a)." Moreover, in Bandura's findings, he propositioned that one's SE can impact their perseverance and effort towards activities they engage in (Bandura, 1977a). Due to SE being a belief, overestimation of one's abilities is often noted by researchers as a common trend, although this may contribute to a student's perseverance when faced with academic challenges (Artino, 2012; Bandura et al., 1999; Bush et al., 2022; Kuchynka et al., 2021; Pajares, 1996).

Bandura also coined Social Cognitive Theory (SCT), where ones SE belief will influence their academic and career choices, and therefore, their performance outcomes (Stewart et al., 2020). Bandura defined SCT as subscribing to a "model of emergent interactive agency [where] persons are neither autonomous agents nor simply mechanical conveyers of animating environmental influences. Rather, they make causal contribution to their own motivation and action within a system of triadic reciprocal causation (Bandura, 1989)." To expand on triadic reciprocal causation, personal factors (attitudes and values), behavioral factors (choices and actions), and environmental factors (actions of others and social context) influence individuals choices and actions and lead individuals to choices that are more certain, or in other words performed with more confidence (Bandura, 1977b). Tracey identified that when SE perceptions and one's interests align, feelings of certainty in occupational choices increases (Tracey, 2010).

A derivation from SE and SCT, Social Cognitive Career Theory (SCCT) suggests ones career choices comes from interactions between multiple career elements, including environmental, behavioral, and personal factors (Lent et al., 1994). SCCT has adopted a three-factor interaction model of career theory: Firstly, SE aims to question "can I do this?", followed by outcome expectations that questions "what will happen if I do this?", and lastly, personal goals further questions "how much do I want to do this?" (Wang et al., 2022). These three factors mimic triadic reciprocal causation witnessed in SCT (Lent et al., 1994). The steady theoretical progression through SE, SCT, and SCCT have provided a valuable lens through which we can examine students' interest and persistence in STEM fields (Bandura, 1977a, 1977b, 1989; Bandura et al., 1999; Lent et al., 1994). By understanding that SE contributes to interest and persistence in STEM, it is valuable to review the elements that influence SE, like learning styles and intelligence theories, and their interplay with SCT and SCCT (Bandura, 1977a; Bandura et al., 1999).

PEDAGOGICAL PRACTICES AND SELF-EFFICACY

Entity and incremental theories of intelligence are thought to exist as a spectrum, where entity intelligence is believed to be a "fixed" trait and incremental intelligence is believed be "malleable." An abundance of research supports that one's intelligence beliefs will impact their academic achievement and persistence, where incremental intelligence theorists have more positive outcomes in terms of academic success than their entity intelligence theorist counterparts (Buckley et al., 2019; Good et al., 2012).

Congruent with Bandura's SE theory, incremental intelligence beliefs were associated with challenge seeking, perseverance, and effort towards an activity, while entity intelligence beliefs were associated with fear of failure and avoiding challenges (Bandura, 1977a, 1989; Buckley et al., 2019; Good et al., 2012). Moreover, a meta-analysis exploring implicit theories of intelligence found that globally, students with more incremental beliefs earned higher grades throughout secondary and post-secondary education (Costa & Faria, 2018). Notably, incremental intelligence beliefs primarily impact students during their STEM education and less in the workforce, as these intelligence beliefs are strong predictors in STEM persistence and those who held incremental intelligence beliefs were more likely to enter STEM (Buckley et al., 2019; Good et al., 2012). Additionally, because incremental intelligence beliefs directly influences SE, SCCT is also strongly altered by incremental intelligence beliefs, in which incremental intelligence beliefs positively influence the trajectory of ones' career choices within STEM (Buckley et al., 2019; Good et al., 2012; Wang et al., 2022). Taken together, incremental theories of intelligence impact individuals in the SCCT framework by leading them to more certain choices, where certainty is how confident one feels in that choice (Bandura, 1977a, 1977b; Lent et al., 1994; Wang et al., 2022).

Self-efficacy is influenced not only by one's belief in their ability to learn and grow (e.g. incremental intelligence), but also by their willingness to engage with the content they are attempting to master. Active learning positively contributes to students SE by fostering an environment of collaboration that promotes academic success and in return supports STEM retention, especially for underrepresented groups (Freeman et al., 2014; Kalaian et al., 2018; Theobald et al., 2020).

Active learning has been defined and redefined several times by various scholars (Theobald et al., 2020), however, Freeman et al. collected 338 written definitions by audience members at universities prior to seminars on active learning and coded the responses to generate the following definition: "Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (Freeman et al., 2014). In contrast, researchers defined traditional or passive lecturing as "continuous exposition by the teacher" where the student was assumed to be notetaking and sparingly asking questions (Freeman et al., 2014; Theobald et al., 2020). Freeman et al., also discovered through a meta-analysis that active learning pedagogies lead to higher examination scores while decreasing failure rates compared to students taught the same material through traditional passive learning methods (Freeman et al., 2014).

Active learning approaches vary from methods to elicit a student's response like kahoot or clicker questions to recreating learning environments such as problem based learning (Idsardi et al., 2023). A meta-analysis investigated pedagogical literature on small group learning compared to lecture-based learning in technology and engineering courses and results showed each form of small group pedagogies appear to promote academic success (Kalaian et al., 2018). Moreover, students who encounter collaborative and cooperative learning strategies have accelerated and improved academic achievement (Kalaian et al., 2018).

As an extension of active learning, collaborative learning is a blanket term that refers to several pedagogical approaches in small group learning settings, such as peer tutoring, study groups, problem-based learning, and even cooperative learning (Smith & MacGregor, 1993). Defining collaborative learning is another challenge stemming from its concurrent development by multiple scholars (Bruffee, 1984; Johnson, 1970; Wiener, 1986). In contrast, cooperative learning is defined by "the instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson & Johnson, 1987), which emphasizes interdependence in teams. Collaborative and cooperative learning share several overlapping traits and pedagogical theories, such as being student-centered and focusing on substantive concerns (Bruffee, 1999). Although they are sometimes used synonymously, they differ primarily in their use of structure, with cooperative learning requiring a more tightly-structured approach (Barkley et al., 2014). Despite their differences, collaborative and cooperative learning frequently co-exist in many group settings (Jeong & Hmelo-Silver, 2016).

It is well accepted that entering college with the intent to pursue STEM is usually accompanied by high SE perceptions, followed by a decrease in SE when students are met with academic challenges (Kuchynka et al., 2019; Liu et al., 2014). These drops are partially explained by self-doubt and anxiety that students often experience transitioning from high school to college but leave more parameters unanswered than met (Kuchynka et al., 2021; Rosenthal et al., 2011).

To further explore what experiences build SE during collaborative learning, researchers assigned two quantitative biology tasks (e.g. calculating Hardy-Weinberg equation and modeling population growth) to students and then analyzed responses via surveys (Aikens & Kulacki, 2023). Students reported that completing practice problems and homework raised their SE perceptions (Aikens & Kulacki, 2023). Moreover, checking answers with peers, teaching peers, and receiving help from peers and the instructor also increased their SE perceptions (Aikens & Kulacki, 2023).

Depending on the individuals initial SE, some experiences may influence students differently (Aikens & Kulacki, 2023).

Notably, SE beliefs for underrepresented minorities may fluctuate more than their represented counterparts because they are at higher risk of academic isolation, bias, and lower levels of support and/or recognition (Kuchynka et al., 2021). This urges student participation in active learning environments, mentoring, and undergraduate research experience (UREs) to help close the gap between underrepresented and represented students (Kuchynka et al., 2021). Therefore, academic assistance is necessary to students with initially lower SE beliefs (Aikens & Kulacki, 2023). Institutionally, adoption of active learning (frequent discussions and/or checkpoints) and providing students opportunities to demonstrate their skills will build SE perceptions positively (Aikens & Kulacki, 2023). Although students' SE beliefs are strongly correlated with their persistence and retention in STEM fields, SE is not fully predictive of STEM outcome; (Stets et al., 2017; Tracey, 2010; Williams & George, 2014) a student's decision to pursue and remain in a STEM field is also influenced by how well they feel that they belong in that field (SOB), as well as how strongly they identify with their role as a scientist (SI) (Sax et al., 2018; Stets et al., 2017; Tracey, 2010; Williams & George, 2014).

SENSE OF BELONGING AND STEM RETENTION

Sense of Belonging (SOB) is defined as "students' sense of being accepted, valued, included, and encouraged by others (teachers and peers) in the academic classroom setting and of feeling oneself to be an important part of the life and activity of the class" (Goodenow, 1993; Rainey et al., 2018). A more recent characterization of SOB at the undergraduate level is "students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community" (Strayhorn, 2018). SOB goes far beyond STEM content but has a profound impact on students' decision to remain in STEM fields.

Students with strong feelings of SOB have higher rates persisting to graduation in STEM domains (Strayhorn, 2012). Curricular and co-curricular support programs that incorporated leadership skills, career development, peer mentoring, and undergraduate research opportunities had significantly higher STEM persistence rates than their nonparticipating counterparts (Strayhorn, 2012). Notably, results suggests that students may persist in STEM degrees if they feel a high SOB to the field, despite low SOB in their institutional environment (Hansen et al., 2023), suggesting that these activities may positively change SOB feelings in the face of lacking institutional support. In computing fields, how students' perceived their acceptance within their institutional department and with peers was crucial for facilitating belongingness (Sax et al., 2018). Some methods may foster positive SOB more than others: while inclusive pedagogies helped facilitate peer and department support, general support from others may be more important for fostering a SOB (Sax et al., 2018).

Self-perceptions can have an impact on a student's SOB and academic achievement as demonstrated by a longitudinal study that accessed a calculus course and found that women's SOB to math predicted their academic choices and accolades, reminiscent of Bandura's SCT, and altered women's perceptions of their learning environment (Good et al., 2012). Furthermore, the more women perceived their learning environments as having entity views of math intelligence and/or stereotyping, the less they felt they belonged (Good et al., 2012). The inverse is true for women who perceived their learning environment as having incremental views of math intelligence (Good et al., 2012). However, if a student's SOB was high, math grades and intent to pursue math was mediated, despite the negative impact of incremental theories of intelligence and stereotyping, suggesting that some factors can have more impact than others (Good et al., 2012).

More information on theories of intelligence show a professors held intelligence theories is associated with students own perception of intelligence theories, suggesting that students follow their professors as role models (Lytle & Shin, 2022). This could be a predictor of students STEM engagement and retention (Lytle & Shin, 2022). This professor influence is important because one's intelligence belief can predict STEM interest, SE, and SOB (Lytle & Shin, 2022).

Instructor influence trends appear to also impact other student age groups, as high school students with little to no support in fostering their SI in science, engineering, or medicine were more likely to leave their respective goals, and therefore not pursue postsecondary education in these sectors (Aschbacher et al., 2010). The role of teacher and professor as instructor/expert in engaging their students and fostering SOB is crucial, but educators also serve as mentors and role models for their students, and this mentor role also influences how students approach STEM and to what extent they persist in the face of adversity or challenge.

Mentorship is another useful tool in understanding STEM students' SOB. In addition to mentorship as an early influencer of career success (Newell & Ulrich, 2022), faculty mentoring was found to have significant impact on intent to pursue STEM, as well as retention in STEM (Hernandez et al., 2020). Perceived professor care can also be an indicator for STEM retention and SOB (Rainey et al., 2019); students who felt that their professors cared about them and their learning were more likely to remain in their STEM major (Rainey et al., 2019). Overall, women reported feeling less professor care than men regardless of whether they remained in the major (Rainey et al., 2019), which may have implications for addressing the gender disparity in STEM fields. An overlap between perceived professor care and SOB within STEM was noted, where a high SOB was correlated with higher perceived professor care, and vice versa for students who felt their professors did not care about their learning (Rainey et al., 2019). Students who encountered active learning preferred active learning over lecture based learning, and those who persisted in STEM reported a higher perceived professor care when experiencing active learning methods (Rainey et al., 2019).

SCIENCE IDENTITY AND SELF-PERCEPTIONS IN STEM

Through various experiences, a student's science identity or STEM identity is developed (both hereafter referred to collectively as SI). SI is defined by "one's recognition by self and others as a STEM person" (Carlone & Johnson, 2007; Merolla et al., 2012; Murphy & Kelp, 2023; Robinson et al., 2018; Stewart, 2021; Williams & George, 2014). A STEM identity framework is comprised of three dimensions: competence, or one's knowledge and understanding of STEM; performance, or one's ability to engage in various STEM practices; and recognition, or being seen by others and seeing one's self as a STEM person (Carlone & Johnson, 2007; Merolla et al., 2012; Murphy & Kelp, 2023; Robinson et al., 2018; Stewart, 2021; Williams & George, 2014). This framework acknowledges that SI is shaped by demographics like gender and race, as well as explicit or implicit bias that the student may experience from STEM faculty (Carlone & Johnson, 2007; Merolla et al., 2012; Murphy & Kelp, 2023; Robinson et al., 2018; Stewart, 2021; Williams & George, 2014). Performance avoidance orientation, where students avoid challenges in fear of appearing incompetent, may discourage SI development because mistakes are a necessary part of learning, whereas participation in research and engaging with mentors has been correlated to more positive SI beliefs.

Research investigating how SI and self-perceptions develop were studied over five years with heterogeneous patterns emerging with three latent classes (Robinson et al., 2018). The first being "high with transitory incline" characterized by high SI in the first year of college, with slight decrease over the course of four years in college but remaining very high throughout (Robinson et al., 2018). Secondly, "moderate-high and stable" where students had moderately high SI in their first year with little change over four years in college (Robinson et al., 2018). Lastly, "moderate-low with early decline" was organized as a low SI in the first year of college with a sharp decrease, with less dramatic decreases in the following years of college (Robinson et al., 2018). These findings suggest that identities are relatively stable once a commitment is made (Robinson et al., 2018). Moreover, the "moderate-low with early decline" latent class is consistent with the common notion that college is a time for change in individuals (Eccles, 2009; Robinson et al., 2018).

Taken together, Banduras SCT and SE theories appear to account for a student's self-perceptions on their capabilities to perform tasks, where SE can predict outcomes and expectations. Scholars from the 1990's point to SE as the link between college education and career choices (Hackett & Betz, 1989; Lent et al., 1994; Pajares, 1996). Therefore, students self-perceptions of their SI and SE could be used to make changes at the institutional level to increase student success in STEM majors long term (Williams & George, 2014).

UNDERGRADUATE RESEARCH EXPERIENCES FOSTER SE, SOB, AND SI

While SE, SOB, and SI individually have meaningful impact on a students' desire to pursue STEM and their persistence in remaining in the field, students' STEM pursual and retention assessed at the intersection of these three terms may provide additional insight and valuable information. SE, SOB, and SI are inherently linked – e.g. a student may measure their SE through the lens of their perceptions of themselves as a scientist or feel more at-home in a field in which they perform well.

Reciprocal relation analysis found that students who reach a strong STEM persistence earlier in STEM developed a higher sense of SE and SI, leading them to higher rates of research engagement compared to students with lower STEM persistence, thus impacting SOB positively (Hernandez et al., 2020). Moreover, early participation in STEM-based research also exhibited an increase in STEM degree completion in science, engineering, and mathematic degrees, as well as a slight increase in GPA (Rodenbusch et al., 2016).

STEM undergraduates were surveyed about their scientific communication skills, SE, and SI to explore students' attitudes towards community outreach (Murphy & Kelp, 2023). Results found that undergraduate students have a desire to engage with the community but lack the opportunities to do so (Murphy & Kelp, 2023). Those students with higher levels of SE, SI, and/or more confidence in scientific communication showed more interest in STEM community engagement (Murphy & Kelp, 2023).

One of the most effective ways to positively impact SE, SI, and SOB through activities is student participation in Undergraduate Research Experiences (URE's), where these main three components interplay on one another and impact choice outcomes like STEM persistence and STEM career readiness (Bush et al., 2022; Erin Pearce, 2022; Gamage et al., 2022; Hernandez et al., 2020; Newell & Ulrich, 2022; Sax et al., 2018; Schmidt et al., 2020; Tan-Wilson et al., 2020).

Early exposure to positive STEM experiences is crucial for facilitating ones SOB (Hernandez et al., 2020). Newell and Ulrich discovered several central themes associated with URE's that equips graduates with soft skills and career competencies that the STEM workforce requires, while reinforcing students' SOB and SE feelings (Newell & Ulrich, 2022). URE participants acquire increased content knowledge, including forming a deep understanding of science concepts and techniques, as well as the research process. National Association of Colleges and Employers (NACE) defines career readiness competencies such as teamwork, communication, critical thinking, leadership, and time management. URE's allowed students to practice these competencies related to their own personal and professional development. Therefore, research suggests URE's facilitated required skills and abilities to joining the workforce in STEM while providing a safe environment to explore the scientific method that developed a sense of confidence, independence, and perseverance in science, all which contribute to ones SOB and SI. Another identified theme was the impact of mentorship that URE's facilitated, where mentorship affected a student's development in all central themes. From here, mentorship was identified to influence early career success by guiding the student to become a well-rounded scientist. Furthermore, students were able to gain insight about the requirements of an academic research career (Newell & Ulrich, 2022). In corroboration of these findings, Hernandez et al reciprocal relation analysis also found that early integration (participation) in STEM lead to research engagement and this developed a stronger SI (Hernandez et al., 2020).

During a pre-service teaching URE, mentors stressed how undergraduates were an integral part of the program who taught STEM topics to k-12 students (Erin Pearce, 2022). This was a crucial decision within the program, as it increased students' STEM and pedagogy understanding while exposing them to an implemented research design, with the opportunity to collaborate with peers for constructive feedback that facilitates SOB (Erin Pearce, 2022). This opportunity with their mentors further developed their SI in a positive manner (Erin Pearce, 2022). In the same URE, students' perceptions of themselves in STEM positively changed and their perceptions on STEM's societal importance and educational research was improved (Erin Pearce, 2022).

Additionally, two consecutive summer URE's were analyzed, and results demonstrated that URE students largely broadened their STEM content knowledge (Gamage et al., 2022). Moreover, students reported an increase in career readiness competencies such as interpreting data, statistical analyses and troubleshooting, accompanied by personal and professional growth where participants felt familiarity with the research and increased independence/autonomy (Gamage et al., 2022).

Another example showcases a pre-service learning program where students increased their science teaching SE and interest in pursuing teaching, while the program honed in on competencies such as teamwork, leadership, and communication which is crucial when joining the workforce, suggesting similar low barrier entry programs in different STEM domains may increase interest and intent to these fields, mitigating negative SE perception fluctuations (Bush et al., 2022).

To further elaborate, a pre-service learning course called "Chemistry 1898" increased undergraduates SE perceptions in science concepts and science teaching, while simultaneously increasing student retention rates in chemistry (Schmidt et al., 2020). Additionally, "Chemistry 1898" encouraged students to think about societal needs STEM domains could address, making students ponder about pursuing STEM careers in the future (Schmidt et al., 2020).

Lastly, during a one-year URE, life science majors were paired with other STEM discipline mentors and peers to create an interdisciplinary life science project that enhanced communication, teamwork, and science understanding (Tan-Wilson et al., 2020). Logistical regression analysis found that students that interacted with their mentor in their distinct STEM discipline was a significant predictor of occupation choice (Tan-Wilson et al., 2020).

Collectively, various URE's have shown to be beneficial to career development, SOB, and SE in STEM domains (Bush et al., 2022; Erin Pearce, 2022; Gamage et al., 2022; Hernandez et al., 2020; Hernandez et al., 2018; Newell & Ulrich, 2022; Rodenbusch et al., 2016; Sax et al., 2018; Strayhorn, 2012; Tan-Wilson et al., 2020). These types of experiences may serve as one mechanism used to help bridge the gap in STEM representation.

OCCUPATIONAL CHOICE AND STEM RETENTION

Students who remain in STEM fields throughout their education may enter the STEM workforce, though this decision depends on a wide variety of factors as outlined in SCCT, such as background context, learning experiences, interests, SE- and outcome-expectations, and proximal contextual influences (Lent et al., 1994). The intersectional nature of SE, SI, and SOB indicate that these three factors may all contribute to students' eventual career decisions.

Employees and employers both benefit from occupational choice congruency, wherein the employee's interests and SE perceptions are aligned with their occupation, via increased productiveness and heightened job satisfaction (Assouline & Meir, 1987; Tsabari et al., 2005). Occupational choice certainty is correlated with both interests and SE; although interest congruence had a greater impact than SE, a substantial interaction between the two still predicted career certainty (Tracey, 2010). Underrepresented populations in STEM may face additional hurdles in SE, SI, and SOB relative to their peers which may contribute to decreased overall representation in STEM fields (Hansen et al., 2023; Holman et al., 2018; Rainey et al., 2019; Robinson et al., 2018; Sax et al., 2018; Strayhorn, 2012; Williams & George, 2014).

To investigate what lead underrepresented students into STEM occupations, researchers looked at graduated students and inquired if their employment status was science related or not, then analyzed other parameters that played a role in occupation choice (Burke & Stets, 2022; Stets et al., 2017). Results show that only SI significantly influenced joining the STEM workforce upon graduating compared to other parameters, such as SE in science, intention to pursue STEM fields, and demographic factors, which is consistent with social structures where identities move individuals into compatible positions (Burke & Stets, 2022; Stets et al., 2017). Although SE, SOB, and career intent are strong predictors of STEM persistence, SCCT poses that SI is most influential to career certainty because of the notion that college is a time for change and that once a commitment is made towards a change, identities are often stabilized (Eccles, 2009; Robinson et al., 2018).

It is important to remember that SE perception is a primary force behind SI beliefs (Hackett & Betz, 1989; Lent et al., 1994; Pajares, 1996). Overall, underrepresented individuals with a strong SI are more likely to enter the STEM workforce after graduation, where significant correlation between choosing to enter a science occupation was associated with higher senses of SE and SI (Burke & Stets, 2022; Stets et al., 2017). Interestingly, their GPA is a main predictor of their SI, in which SI trends will follows the direction of their GPA (e.g. higher GPA will equate to a higher SI) (Burke & Stets, 2022; Stets et al., 2017). The role of SE in shaping SI presents an opportunity to reevaluate Lent's SCCT and address the relationship between GPA and a student's SE beliefs, as SCCT has shown that SE contributes to interests and persistence in STEM domains (Burke & Stets, 2022; Lent et al., 1994; Stets et al., 2017).

Altogether, SE leads students towards or away from interests and propels them forward in certain paths, where science paths may lead students toward science occupations, and parameters like GPA can be an early predictor of STEM persistence (Burke & Stets, 2022; Lent et al., 1994; Pajares, 1996; Stets et al., 2017).

Using the tripartite integration model of social influences (TIMSI), scientists examined the impact of URE's to predict scientific research career persistence intentions, where TIMSI provided the base understanding of social influence on students' choice to enter STEM careers and culture (Hernandez et al., 2018). Results found that early in the URE, there was a decline and rebound pattern in persistence intentions, especially in students who felt lower project ownership during their URE (Hernandez et al., 2018). However, the exception was students with high project ownership during their URE maintained high levels of persistence (Hernandez et al., 2018). Notably, faculty mentors acted as role models, increasing student's embodiment of community values in science, which translated into increased students scientific career persistence intentions (Hernandez et al., 2018).

Theoretical processes, like SE theory and goal theory, work primarily through the identity processes (Burke & Stets, 2022; Stets et al., 2017). Meaning that without a strong SI, other processes are minimal in minority students' occupation choice (Burke & Stets, 2022; Stets et al., 2017). Although more research should confirm this finding, it does demonstrate how identities formed in educational institutions transfer to other places like the workforce (Burke & Stets, 2022; Stets et al., 2017).

CONCLUSION

While the gap in representation in the STEM fields is slowly diminishing, there is still much work to be done in order to promote an equitable educational and work environment. Although representation of women and minorities has improved during the past decade, these groups are still underrepresented in many STEM disciplines and fields. Addressing the root cause of this underrepresentation requires a strong understanding of the factors that contribute to STEM pursual and retention, such as SE, SOB, and SI, and understanding how these factors are experienced differently by different populations.

Statistical analyses suggest that underrepresented groups, including women and people of color, are disproportionally excluded from STEM spaces, including educational and workforce settings, leading to these groups leaving STEM altogether (Brainard & Carlin, 1998; Clark et al., 2016; Hernandez et al., 2020; National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023; Sax et al., 2018; Williams & George, 2014). STEM exclusion is largely reported by marginalized groups and this exclusion contributes to negative SOB feelings, which is directly correlated with lower SE and SI perceptions, which all negatively contribute to STEM retention and career intent. However, the inverse is true of positive STEM spaces where students typically feel a beneficial enhancement to their SOB, SE, and SI beliefs when they are in nurturing environments to foster their SI in particular (Brainard & Carlin, 1998; Estrada et al., 2016; Hernandez et al., 2020; Holman et al., 2018; Robinson et al., 2018; Sax et al., 2018; Williams & George, 2014).

Another major component is students' self-perceptions, not only on their SOB, SE, and SI, but also their perception on intelligence beliefs (entity or incremental) and whether they encounter lecture versus active based learning structures that may further develop their perception of intelligence beliefs (Freeman et al., 2014; Kuchynka et al., 2021; Theobald et al., 2020). Furthermore, active learning environments leads to increased feelings of SE and SI, because the student takes an active role in the learning process, contrary to passive listening via lectures, and some researchers posit that it is even more impactful for underrepresented groups (Buckley et al., 2019; Bush et al., 2022; Costa & Faria, 2018; Freeman et al., 2014; Idsardi et al., 2023; Kalaian et al., 2018; Kuchynka et al., 2021; Rainey et al., 2019; Theobald et al., 2020).

Regardless, positive and negative feelings towards determining parameters like SOB, SE, and SI similarly follow their respective positive or negative trend in career intent and pursuance

(Claydon et al., 2021; Estrada et al., 2016; Hernandez et al., 2020; Tan-Wilson et al., 2020). SCCT continues to provide a valuable lens to view STEM pursual and attainment by acknowledging that identities contribute the most to career choice certainty, where individuals are more confident in their career choice and is oftentimes accompanied by a stronger intent to pursue a specific domain (Bandura, 1977a, 1989; Bush et al., 2022; Claydon et al., 2021; Hernandez et al., 2018; Lent et al., 1994; Rodenbusch et al., 2016; Stewart et al., 2020). To increase the number of students pursuing STEM and their succeeding career entry in STEM, changes must occur in several avenues to address the shortcomings of the current STEM educational and workforce system contributing to the workforce gap (Brainard & Carlin, 1998; Claydon et al., 2021; National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023; Robinson et al., 2018).

Firstly we must address a major gap in literature which is longitudinal studies investigating a plethora of discussed topics, as the majority of primary research is short-term (Bush et al., 2022; Erin Pearce, 2022; Good et al., 2012; Newell & Ulrich, 2022; Sax et al., 2018; Stets et al., 2017; Williams & George, 2014). We suggest post-secondary STEM students be studied from the beginning of university to one-year post-graduation to inquiry about SE, SOB, SI, and other key topics that aid in retention of students in STEM, potentially through the lens of SCCT. We acknowledge that this research model comes with challenges, but we urge more investigation into these topics because following students throughout their education provides researchers with insightful data that can pinpoint trends and patterns to make inferences about where to make impactful changes.

Moreover, to improve STEM retention and career readiness, STEM instruction changes and teacher development programs are common call to actions for altering our current STEM education (Aldahmash et al., 2019; Sithole et al., 2017). However, implementing plans to educate teachers on various pedagogies and additional training in mathematics and science to teach integrated topics remains to be addressed by institutions (Aldahmash et al., 2019; Sithole et al., 2017). Moreover, implementing active learning methods to classrooms needs more participation to change the common STEM classroom in long-lasting ways (Aldahmash et al., 2019; Freeman et al., 2014; Sithole et al., 2017; Theobald et al., 2020).

Another recommendation is to implement career-related courses for undergraduates. For instance, in an active learning career-related course for biomedical graduate students titled *Skills Development for Diverse Scientific Careers*, students were exposed to topics otherwise not addressed in their curriculum including nontraditional careers, CVs to resume writing skills, business portion of the biotech industry, behind the scenes into clinical trials, and advice about resilience for scientists early into their career (Claydon et al., 2021). By the end of the course, students reported a significant increase in four out of twelve career sectors: government or non-profit, library science, K-12 education, and publishing and/or communications (Claydon et al., 2021). Exposure in courses like these piqued students' interest for several career sectors (Bush et al., 2022; Claydon et al., 2021; Kricorian et al., 2020; Murphy & Kelp, 2023; Newell & Ulrich, 2022). Specific to this course, an increased confidence in career competencies and next steps were attained by students across all career sectors (Claydon et al., 2021). In addition to the current curricula in the course, the creators aim to add guest speakers from career paths not currently covered in the course, like law and science policy (Claydon et al., 2021). One further step to facilitate community outreach and expose students to different career possibilities is university created programs to connect with surrounding organizations within their respective community (e.g. undergraduate research experiences working with K-12 students or library reading programs) (Murphy & Kelp, 2023).

Additionally, URE's have demonstrated their positive impact on students SOB and SI, therefore implementing URE's into a curriculum requirement would be beneficial (Graham et al., 2013). By supplementing traditional laboratory courses with URE courses, students can experience a more impactful and realistic laboratory experience to increase student retention in STEM education, while research labs benefit from student assistance (Graham et al., 2013).

To increase underrepresented minorities persistence in undergraduate STEM, institutional barriers must be addressed. Firstly, holding universities accountable for their publishing their student demographic data, such as incoming students declared major and interests as well as ethnicity, gender, and first-generation status, publicly would increase institutional accountability (Estrada et al., 2016). Secondly, improving the curriculum to include research-based and inquiry-based approaches, like URE's, provide students with more opportunities to develop their SI and SOB (Bush et al., 2022; Erin Pearce, 2022; Estrada et al., 2016; Newell & Ulrich, 2022; Rodenbusch et al., 2016). Thirdly, funding from institutional, federal, and private holders, as well as political recourse to reduce economic disparities in education will improve student resources (Claydon et al., 2021; Estrada et al., 2016). Lastly, finding creative avenues for fostering SOB in underrepresented minorities in STEM like community outreach efforts (Estrada et al., 2016; Murphy & Kelp, 2023). Overall, adopting these strategies to positively influence the institutional system and increase equity among underrepresented groups is valuable to solving the STEM workforce gap and contributing towards a new future for STEM disciplines (Claydon et al., 2021; Estrada et al., 2016; Hansen et al., 2023; National Center for Science and Engineering Statistics, 2023; National Science Foundation, 2023; Tan-Wilson et al., 2020).

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