

Scientists Are Rooted in Community: Advancing an Ecological Perspective to Support Community Engagement in STEM Education

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Chapter Highlights

The following points outline a community-centred perspective on STEM education, emphasising the role of sociocultural contexts, student identity, and theory-driven practices in supporting meaningful and sustainable participation in STEM.

- **Challenging Deficit Beliefs** – The practice of science is often believed to be an isolated pursuit – inaccessible and indifferent to broader community involvement. While this master narrative continues to shape perceptions of scientific work, this chapter challenges the belief that science operates independently from the community.
- **Guiding Questions** – I interrogate the following questions: What are the students' community roots that help them flourish in their STEM programs? In what ways do students nourish these roots through their STEM education? How can STEM education programs work to help students' thrive through community engagement?
- **Community Connections as Roots** The existing literature tells us that community engagement is a vital yet often overlooked component of STEM education. I use an ecological metaphor – that of roots – to support this argument. Students' communities function as critical roots that ground and sustain students' scientific interests and altruistic ambitions. This foundation of support helps students flourish both within and beyond their STEM programs.

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Introduction

Professional scientists, education researchers, and students alike hold misconceptions about the relationship between the scientific enterprise and broader communities. Among scientists, there is widespread belief that the practice of science is – and is best kept – separate from the broader public. One manifestation of this belief is the tendency of scientists to discount the benefits of citizen science ventures and underestimate the public in cultivating quality scientific data (Burgess et al., 2017; Riesch & Potter, 2014; Sullivan et al., 2014). Likewise, some of the education literature has advanced notions that students' communities – especially first-generation or immigrant communities – may lack necessary knowledge and skills to support students in STEM (Milner-Bolotin & Morrato, 2018; Suarez-Orozco & Suarez-Orozco, 2000) or promote “disorganized” environments for learning (Jensen, 1969; Lewis, 1969). Among students, survey research indicates that students perceive STEM departments to be individualistic, exclusive, and competitive (Garibay, 2018; Pawley 2019; Seymour & Hewitt, 1997). These beliefs not only collectively portray science as a field with little overlap with broader community interests but also as a difficult arena for this collaboration to take place. In short, much of the previous research traditions have focused on the challenges, rather than potential, of integrating community engagement into STEM education.

This chapter challenges these deficit-laden beliefs. Instead, I argue that community engagement is an important yet underutilized component of effective STEM education. Specifically, STEM community engagement fulfills three opportunities for growth by promoting robust science learning, improving retention, and advancing equity. First, science learning is enhanced when students address personally relevant community-based problems with scientific solutions (Chiu et al., 2023; Wiseman et al., 2020). Second, STEM retention rates also improve when students feel that scientific disciplines will serve “as a vehicle for their altruistic ambitions” (Carlone & Johnson, 2007, p. 1199). Third, several studies indicate that underrepresented minority (URM) students in STEM are more likely to exhibit communal intentions than their non-URM peers (Garcia, 2024; Garibay, 2015; McGee, 2016; McGee & Bentley, 2017), which means that we can better support these students by tending to their communal goals. This chapter supports these arguments with an extended metaphor of students' ties to communities as “roots” that undergird their success in STEM and connect them to the wider scientific ecosystem. Through an ecological perspective, we gain a more comprehensive understanding of the myriads of ways that STEM students intend to and already participate in community engagement, as

well as how we can nurture their growth as both scientific scholars and community leaders.

The rest of this chapter proceeds as follows. First, I introduce and draw connections between three theoretical frameworks – Ecological Systems Theory (Bronfenbrenner, 1979), Goal Congruity Framework (Diekman et al., 2010), and Community Cultural Wealth (Yosso, 2005) – that are valuable to consider when integrating STEM education and community engagement. The second section puts these frameworks in context through discussion of STEM students’ communal roots – before, during, and after their undergraduate experience. It is here that this chapter most directly challenges the notion of ideal separation between science and community. This chapter concludes with a review of curricular and pedagogical practices that sustain students’ community roots and care for their future altruistic endeavors in science. Ultimately, we see that both STEM students and scientists alike are rooted in community.

Theoretical Groundings

For community engagement to flourish within STEM education, it is imperative that we first conceptualize what it means to be in community more generally. Bronfenbrenner’s (1979) Ecological Systems Theory provides a robust definition that accounts for individuals’ interactions with different forms of community. With this definition at the forefront, we can draw from Diekman and colleagues’ (2010) Goal Congruity Framework for additional insight into how individuals navigate through various roles while in negotiation with their communities. The final theoretical framework – Community Cultural Wealth (Yosso, 2005) – provides a detailed understanding of how individuals draw support from various communities throughout their time before, during, and after their formal STEM education.

Defining Community: Ecological Systems Theory (1979)

The field of ecology explores the interactions between living organisms and their environments (Taylor, 1936). In his seminal work, *The Ecology of Human Development* (1979), psychologist Urie Bronfenbrenner advanced an ecological perspective to examine the interplay between individuals and their environments within the social sciences. Bronfenbrenner observed that much of the previous literature had considered the role of environment in shaping individual development, yet there was no theoretical framework that explicitly defined the components of the environment (Shelton, 2018).

At its core, Ecological Systems Theory posits that individuals experience

growth both in response to their changing environments and due to their active participation in them (Bronfenbrenner, 1979). The theory is grounded in a constructivist paradigm, because individuals are viewed as active participants in their growth and development (Cobb & Yackel, 1996; Sfard, 1998; Shelton, 2018). Individuals experience constant adaptation to their environment throughout this process (Sfard, 1998). In this chapter, I adapt Bronfenbrenner's notion of environment to be synonymous with community – thus, individuals both influence their communities and are actively shaped by them.

Bronfenbrenner (1979) also characterizes the individual as in simultaneous interaction with nested systems that promote growth and development. As he likens to a series of Russian nesting dolls, such systems represent increasing levels of distance between the individual and various communities (Bronfenbrenner, 1979). Taken together, these systems constitute the ecosystem. These systems are described as follows:

- **Microsystem:** The microsystem is the most immediate and personal level of interaction between the individual and community. Individuals' microsystems may include relations with family, peers, mentors, and colleagues (Bronfenbrenner, 1979, 1994; Harkonen, 2001)
- **Mesosystem:** The mesosystem is a network of microsystems that develop as individuals enter new communities (Bronfenbrenner, 1994). Thus, the relation between an individuals' home and school communities constitutes a mesosystem.
- **Exosystem:** The exosystem does not involve the individual as an immediate participant yet is indirectly impactful on the individuals' growth (Bronfenbrenner, 1994). The media, government, and cultural communities can be considered dimensions of the exosystem.
- **Macrosystem:** The macrosystem represents the societal values and norms that are consistent across the lower-order (micro-, meso-, and exo-) systems that shape how individuals engage with various communities (Bronfenbrenner, 1979, 1994; Harkonen, 2001).
- **Chronosystem:** The chronosystem embodies continuities and changes of individuals and communities over time (Bronfenbrenner, 1994).

This nested systems structure defines the community in various ways. Community consists of an individual's immediate relations (i.e. with family, peers, teachers, colleagues) and broader influences (i.e. with cultural groups,

institutions). Individuals experience reciprocal interactions with these communities that provide feedback on their role within the collective. Bronfenbrenner (1979) emphasizes that the notion of reciprocity marks a significant departure from previous literature on socialization processes. Specifically, he argues that previous literature has focused heavily on how the environment can affect the individual but has yet to thoroughly explore how the individual can shape their environment in turn or how the individual engages with systems beyond dyadic interactions.

Ecological Systems Theory also considers how individuals situate themselves within a community. Bronfenbrenner (1979) defines an individual's role to be "a set of activities and relations expected of a person occupying a particular position in society" (p. 85). As time progresses, the individual experiences ecological transitions as a result of changing roles or settings within the community (Bronfenbrenner, 1979). The study of individuals' growth within a broader community – and the multitude of interactions therein – is deemed development in context (Bronfenbrenner, 1979; 1994; Shelton, 2018).

This broad interpretation of community serves us well in the modern STEM education context. First, a plethora of research shows that students' STEM aspirations are shaped by many influences ranging from the microsystem (e.g. parents, teachers) to the macrosystem (e.g. cultural norms, values) (Garcia, 2024; Garriott et al., 2017; George & Kaplan, 1998; Jaumot-Pascual et al., 2023a; McGee & Bentley, 2017; Simunovic & Babarovic, 2020; Starr et al., 2022; Tey et al., 2020). For example, Garriott and colleagues (2017) used path modeling to explore the relationships between parental support, students' engineering expectations, self-efficacy, and engineering persistence among first-generation college students. They found that parental support had significant positive downstream effects on students' engineering self-efficacy and outcome expectations, which both in turn predicted students' engineering persistence. Additionally, Native American students cited the value of giving back to their community as a strong motivator to persist in STEM in the face of setbacks (Jaumot-Pascual et al., 2023a). Second, an ecological approach moves us forward from the "conquer nature" paradigm that has dominated justifications for rigorous STEM education (Beckwith & Huang, 2005; Garibay, 2015; 2018; Vaz, 2005). The National Academies of Sciences (2007) best exemplifies this paradigm in its landmark report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. The report called attention to the decline of scientific and economic prosperity among the American workforce compared to other

countries and put forth actionable strategies for reversing this trend. It is undoubtedly valuable to consider how STEM education can further national goals, attract and retain capable future scientists, and improve our overall quality of life. However, it is likewise important for STEM education to deepen our collective understanding of the natural world by seeing the world as it is rather than only its potential for future use. Bronfenbrenner's (1979) study of reciprocity and development in context enables us to advance a symbiotic relationship between individuals and surrounding communities.

In the next section, I connect Bronfenbrenner's (1979; 1994) notion of community – specifically, the development in context approach – to Diekman and colleagues' (2010) Goal Congruity Framework. This framework shows how individuals navigate and negotiate various roles in processes that Bronfenbrenner would characterize as ecological transitions.

Navigating Community: Goal Congruity Framework (2010)

Diekman and colleagues' (2010) Goal Congruity Framework (GCF) is an important tool to analyze how individuals navigate various communities. Specifically, the framework highlights how individuals' motives and values affect their feelings of congruence within particular roles (Diekman et al., 2010; Diekman et al., 2017). Individuals are likely to seek out roles that best align with their beliefs and exit roles that conflict with their beliefs. Thus, individuals continually realign themselves within networks that allow them to actualize their goals. The authors outline this process in three phrases:

- **Anticipated (in)congruity:** This initial phase sees individuals anticipate feelings of congruence or incongruence prior to entering a specific role. These beliefs constitute individuals' goal affordances, which are described as beliefs about whether certain roles support or hinder particular goals. These perceptions lead to increased or decreased motivation to enter the role (Diekman et al., 2017).
- **Experienced (in)congruity:** In this phase, individuals' anticipated (in)congruity is juxtaposed with their actual experiences within a role (Diekman et al., 2017). Individuals receive feedback from their environment as to whether their values align with the community, and thus, whether they fit within a given role (Kristof-Brown et al., 2005).
- **Seeking (in)congruity:** This final phase sees individuals respond to their experiences by either maintaining congruity or seeking congruity (Diekman et al., 2017). The latter process may see individuals renegotiate their role within the environment,

organization, or community. Or, individuals may choose to leave a role entirely.

Individuals seek congruence through continual feedback between themselves and their environment. The broad definition of environmental influences – as afforded by Ecological Systems Theory – enables us better understand these modes of feedback.

The Goal Congruity Framework has been successfully utilized to study students' STEM ambitions. A plethora of studies have found that both high school and college students alike perceive STEM fields to afford fewer communal goals than individual goals (Boucher et al., 2017; Cheryan et al., 2015; Clark et al., 2016; Diekman et al., 2010; Diekman et al., 2017; Diekman & Steinberg, 2013; Henderson et al., 2022; Hoh, 2009). However, many students – especially URM students – seek out a STEM degree for altruistic purposes, such as a desire to help their family or serve others (Carlone & Johnson, 2007; Garcia, 2024; Jaumot-Pascual et al., 2023a, 2023b; McGee, 2016; McGee & Bentley, 2017). Thus, these students likely anticipate incongruity between their altruistic ambitions and a STEM education, which in turn reduces their motivation to pursue a STEM degree (Diekman & Steinberg, 2013). Conversely, Steinberg and Diekman (2017) found that students' belief in the communal affordances of STEM degrees predicts their positive feelings towards STEM career paths. Thus, students are more likely to pursue a STEM degree if they perceive overlap between their personal and STEM communities.

Goal Congruity Theory holds additional explanatory power for students' experienced (in)congruity within STEM programs. First, students with direct experience of communal activities – such as mentorship or volunteering – maintain greater belief about communal affordances of STEM programs (Belanger et al., 2020; Montoya et al., 2020; Steinberg & Diekman, 2017). Student mentors likewise experience benefits to their STEM persistence – a testament to Bronfenbrenner's (1979) study of reciprocal interactions. Second, students' exposure to altruistic role models in science has led to heightened science interest (Cheryan et al., 2015; Clark et al., 2016; Gladstone et al., 2024; Gladstone & Cimpian, 2021; Shahali et al., 2017). Third, students' perceived communal affordances in STEM moderates their sense of belonging and persistence within their chosen program (Belanger et al., 2020; Isenegger et al., 2023; Yu et al., 2025). For example, Carter et al. (2021) found that highlighting the altruistic outcomes of a geoscience career are more attractive for students than other reasons for pursuing the

degree (e.g. working outdoors). These findings indicate that STEM degree programs that demonstrate commitment to communal goals are positively received by students, which in turn facilitates higher student retention.

Ecological Systems Theory and the Goal Congruity Framework work in tandem to explore how students both conceptualize community and navigate through community before and during college. Both theories recognize that students have agency to choose to enter and exit various roles in what Bronfenbrenner deems ecological transitions. (Bronfenbrenner, 1979, 1994; Diekman et al., 2010). Importantly, these decisions are driven by continual feedback from both students' micro- and macrosystems (Diekman et al., 2017). Building on Bronfenbrenner's (1979) broad definition of community, the Goal Congruity Framework sheds light on the fact that students' non-communal perceptions of STEM will have disproportionate adverse effects on URM students' retention. This occurs because these students are more likely to maintain communal goals than their non-URM peers (Diekman et al. 2011; Diekman et al., 2017). But how do persistent URM students leverage community support that surmounts these perceived barriers? The third theoretical framework – Community Cultural Wealth (Yosso, 2005) – is valuable for illuminating the many ways that community supports students' success.

Leveraging Community: Community Cultural Wealth (2005)

Yosso's (2005) Community Cultural Wealth (CCW) Framework emerged as a challenge to previous theories of cultural capital. In previous decades, education theories of cultural capital espoused a belief that communities contribute valued capital to society, yet some communities are culturally wealthy while others are culturally poor (see Valencia & Solorzano, 1997; see Valenzuela, 1999). Bourdieu and Passeron (1977) argued that students from culturally poor communities (i.e. Communities of Color) could access greater resources through social mobility. Thus, formal education is a vehicle through which these students can gain entrance into wealthier community echelons. Yosso (2005) drew attention to two core flaws of this perspective. First, the assumption follows that Communities of Color lack certain skills and resources needed to advance socially. Second, the values and outcomes of White communities become the standards upon which all other communities are judged. The CCW Framework addresses these flaws by centering how Communities of Color nurture students' various forms of cultural wealth. Drawing from Solorzano's (1997) tenets of critical race theory in education, the Framework decenters deficit-laden perspectives and

instead highlights the strengths that students bring to educational spaces. The CCW Framework highlights six forms of capital as follows:

- **Aspirational capital:** This form of capital centers how Communities of Color nurture a culture of possibility in the face of obstacles. Yosso (2005) highlights previous scholarship showing how Chicano parents maintain high mobility aspirations for their children despite low educational attainment compared to other demographics (Solorzano, 1992). Similarly, Shelton and Thompson (2023) celebrate how undocumented Latinx students maintain a desire to serve others amidst ongoing immigration uncertainties and political hostilities. Even when URM students did not have clearly defined educational goals, they desired to be successful college students (Perez II, 2017). Within STEM education, aspirational capital was visible in 28 out of the 33 studies included in Denton and colleagues' (2020) recent review. For example, Dika and colleagues (2018) found that aspirational capital was a key motivator for URM students persisting in engineering.
- **Linguistic capital:** Linguistic capital refers to students' skills attained through communication in multiple languages (Yosso, 2005). Multilingual students often develop cross-cultural awareness and literacy when serving as communication liaisons between school and familial communities (Faulstich Orellana, 2003). STEM students and support staff often viewed bilingualism as helpful for their respective career development (Chavez, 2024; Heyman, 2016; Pacheco & Chavez-Moreno, 2021; Zamudio, 2015).
- **Familial capital:** Familial capital refers to students' cultural knowledge nurtured by family and community memories (Yosso, 2005). This form of capital parallels the notions of funds of knowledge among Mexican American communities (Moll et al., 2006) and pedagogies of the home among Chicano communities (Delgado Bernal, 2001; Garcia & Delgado Bernal, 2021). The STEM education literature contains numerous examples linking students' STEM aspirations to their familial backgrounds. Students cite robust family involvement in their learning (Longoria, 2013) – oftentimes sparking their interest in STEM from an early age (Dou et al., 2019; Pattison et al., 2022; Salvatierra & Cabello, 2022; Tolbert, 2017).
- **Social capital:** This form of capital centers how students draw from community networks to facilitate their success (Denton et al., 2020; Yosso, 2005). While in STEM degree programs, students' social capital is often facilitated by peers (Revelo Alonso, 2015). Students' strong

relationships with faculty mentors can also strengthen their social capital (Dika, 2012; Mondisa, 2020; Salazar et al., 2019).

- **Navigational capital:** Stanton-Salazar & Spina (2000) define navigational capital to be the “set of inner resources, social competencies, and cultural strategies that permit individuals to not only survive or even thrive after stressful events but also to draw from the experience to enhance subsequent functioning” (p. 229). Denton and colleagues (2020) found that most scholarship studying navigational capital focused on individuals used resources to maneuver through higher education (see McKnight, 2016; see Mobley & Brawner, 2012). For example, Sausner and colleagues (2024) drew attention to how Black and Latino students navigated through STEM in a variety of ways. Many of these students went out of their way to seize opportunities, even if they did not completely align with their interests, but rather because these opportunities represented a chance for success. While the authors found that female students were likely to acknowledge and utilize external support throughout the program, Black male students tended to absorb a personal responsibility of success.
- **Resistant capital:** This sixth form of capital sees students engaged in oppositional behavior that challenges racism, sexism, ableism, and the status quo (Yosso, 2005). From an early age, children learn about acts of resistance from their parents (Delgado Bernal, 1997; Robinson & Ward, 1991; Villenas & Moreno, 2001). Within STEM education, Revelo and Baber (2018) found that Latino engineering students embodied resistance through role modeling and community outreach. These students also saw their STEM success as their means of resisting deficit narratives about their communities.

Yosso’s (2005) CCW Framework sheds light on how persistent students in STEM utilize community resources as they navigate through STEM education. In the next section, I draw upon previous literature to demonstrate how these resources motivate students’ community aspirations within STEM (Burt & Johnson, 2018; Denton et al., 2020; Habig et al., 2021; Rincon et al., 2020; Rincon & Rodriguez, 2021; Samuelson & Litzler, 2016).

STEM Students’ Community Roots

In a recent piece, Jaumot-Pascual and colleagues (2023a) shed light on the experiences of undergraduate Native American students in the computer science field. Using visual storytelling methods common to Native American groups, students shared their communal motivations for pursuing computer

science. Their stories centered around two themes: a desire to give back and a desire to engage with Native communities. For example, one student – Libby – identified role modeling as one venue for both giving back and engagement, stating “If I’m in computer science as a Native woman, there’s no reason why I can’t take this part of me and try and encourage other people with their own computer science journey” (Jaumot-Pascual et al., 2023a, p. 988). Along similar themes, high achieving Black and Latino students not only cite a desire to give back but are also likely to use their STEM education to act critically and advance justice towards their communities (McGee, 2016; McGee & Bentley, 2017). I see such themes emerging even within my own work within our college admissions team. In this role, I have interviewed a diverse group of high school students interested in pursuing STEM degrees. Countless students center themes of community in our conversations – whether it be around receiving support from family and teachers during school, or engaging with community during co-curricular activities, or valuing careers that enable them to give back to others. I recall one student who spoke about how her part-time job at a senior living facility, and how her engagement with residents therein sparked an interest in studying public health. Ultimately, her goal was to conduct research into dementia-related diseases. Another student described her experience being raised on her family farm in rural upstate New York. She intended to study biology in college, which she felt would allow her to showcase her passion for sustainable agriculture and work in the environmental policy field in the future. These students exemplify a growing population of STEM students, because an increasing number of students cite a desire to “make a difference” as motivation for pursuing a STEM career (Lakin et al., 2021; Mwangi et al., 2021; Vesterinen et al., 2016).

This trend challenges the prevailing views about STEM fields, which is that these disciplines are isolated and individualistic in nature (Boucher et al., 2017; Diekman et al., 2010; Garibay, 2015; Hazari et al., 2010; Nicholls et al., 2007; Parsons, 1997). Diekman and colleagues (2010) found that college students believe that STEM fields are more likely to serve individual rather than communal goals. Students’ image of a scientist is denoted with these individualistic (and often masculine) undertones, even while acknowledging the various roles that a scientist fulfills in different contexts. Parsons (1997) underscored these findings:

Even in the midst of fulfilling his various roles as worker, friend, spouse, and parent, the scientist is characterized as a person who prefers to be left to himself, to be left alone with his mind and his books. (p. 758)

This stereotype endures over two decades later, as evidenced by Pawley's (2019) finding that students conceptualize the ideal engineering student to be a young White male without major external obligations. If these perceptions persist, we risk communal-oriented students – who are also more likely to be from a historically marginalized background – leaving the STEM pipeline altogether. This assertion is supported by both observational and experimental research. For instance, Vida and Eccles (2003) found that valuing collaborative work is negatively associated with both choosing a science career and being employed with a science field. Likewise, students' perceptions that STEM does not afford communal opportunities are repeatedly associated with declines in motivation, interest, and positivity towards STEM careers (Brown et al., 2015; Brown et al., 2018; Thoman et al., 2015). Conversely, students that are shown or participate in community engagement opportunities in STEM do report higher levels of motivation, interest, and positivity (Brown et al., 2018; Thoman et al., 2015; Weisgram & Bigler, 2006)

In response to these findings, Brown and colleagues (2018) deemed community perspectives a “new vantage point” from which educators and researchers alike can promote students' engagement with the STEM pipeline (p. 21). Thus, we must understand the various ways that students leverage and promote community within STEM throughout their educational journeys. The rest of this section details these trends before, during, and after students' college years.

Interest Takes Root: Pre-College STEM Experiences

Students' STEM interests “take root” in their early community experiences. Research shows that many students' STEM interest and community engagement aspirations grew in tandem during their childhood years. Students' childhood years represent a critical period for identity development (Branje et al., 2021; Kroger, 2006). Identity is a complex social construct that involves both internal reflections (i.e. who am I and who do I want to be?) and external considerations (i.e. how do others perceive who I am?) (Gee, 2000; Jones, 2009; Krogh & Andersen, 2013). Importantly, an individual's identity is context-dependent – meaning that their identity is not only shaped, in part, by external recognition but also evolves in response to new interests, roles, and relationships (Carlsson, 2015; Carlsson et al., 2015; Jones & McEwen, 2000). Thus, students' identities shape and are shaped by how they engage in community. These characteristics bode well for examining identity – and by extension, community involvement– via the Ecological

Systems Theory and Goal Congruity Framework.

Identity is an important construct within STEM education, because it shapes students' perceptions of their possible future "selves" (Markus & Nurius, 1986). We aspire for students to see themselves as a "science person" – someone who enjoys and can succeed in science – and thus we must understand how this science identity is cultivated both before and during students' college experiences. This is also important because science identity is a strong predictor of science interest and science career aspirations among students of all ages (Roth & Tobin, 2007; Royse et al., 2020; Starr et al., 2020; Stets et al., 2017)

The Microsystem: Parents and Families

Students' families remain the most immediate community that influences their academic dispositions (Burt & Johnson, 2018; Deng et al., 2023; Dotterer et al., 2009; George & Kaplan, 1998; Madsen et al., 2023; Mak & Chan, 1995; Peralta et al., 2013; Russell & Atwater, 2005; Strayhorn, 2010). Students' families are active participants in their students' education and provide resources and support for their success (Ritter & Mont-Reynaud, 1993), which challenges the deficit views towards ethnic minority families' educational involvement (or perceived lack thereof) in their children's education. Historically, these parents have been falsely stereotyped as uncooperative or apathetic towards their children's education (Comer, 1988; Erikson, 1968), or discredited as aggressive or unreasonably ambitious for their children (Comer, 1988; Lawrence-Lightfoot, 1978). While these sentiments persist in the literature, there is no research or theoretical basis to support these beliefs.

Regarding students' STEM interests, families represent the first microsystem in which students' science interests "take root", which also means that family influences affect the students' future growth within STEM. For example, George and Kaplan (1998) found that parents encourage students to develop pro-science attitudes through engagement with out-of-school science activities and involvement in students' schooling. Burt and Johnson (2018) drew on the interviews with 30 Black men in graduate engineering programs to identify how early influences cultivated their interest in STEM. The authors found that parents employed resistant and navigational capital to promote students' success, specifically by working to enroll their children in advanced courses within school and advancing the shared value of education as an "equalizer" at home. Likewise, Russell and Atwater (2005) highlighted how the parents of African American students in STEM set high expectations for their students' success – a theme that

exemplifies aspirational capital. Aspirational capital among students' family communities is a theme across qualitative studies of STEM students' early science experiences (Samuelson & Litzler, 2016). On a broader scale, the Third International Mathematics and Science Study (TIMSS) found that 8th grade students' perceptions of the utility of science were significantly influenced by their parents' views towards science (Beaton et al., 1998). In all of these studies, parents and immediate family instill within their children pro-science attitudes and curiosity about the world.

The Mesosystem: Teachers, Counselors, and Co-Curricular Activities

Following Bronfenbrenner's (1979) framework, we can consider the mesosystem comprising students' home and school communities in partnership. In this vein, Burt and Johnson (2018) reflect this communal sentiment when they state, "cultivating and nurturing kids' early STEM interests is not a parent vs. teacher binary, but rather a community affair" (p. 265). Teachers are important catalysts for students' interests in STEM (Haney et al., 2002). Teachers that affirm students' potential, rather than limitations, for pursuing STEM subjects foster students' genuine interest in those fields (Brown & Kelly, 2007; Burt & Johnson, 2018; McGee & Pearman, 2014). In one study, teacher enthusiasm for STEM was found to have a positive indirect effect – acting through students' intrinsic motivation – on students' GPA (Jungert et al., 2020). This result shows that teachers can excite students' internal aspirations for success, which then have downstream effects on tangible school outcomes. Additionally, teachers that integrate students' community and cultural history into their curricula strengthen students' aspirational capital (Burt & Johnson, 2018). Other school personnel – such as guidance counselors – can also affect community and students' STEM orientations. The American School of Counselor Association's (ASCA) ethical standards (2022) state that counselors should "promote equity and inclusion through culturally affirming and sustaining practices honoring the diversities of families" (p. 6). Thus, high school counselors should be adept at forging relationships between students' home and school communities. Guidance counselors also provide key information about and advise on postsecondary opportunities and thus influence students' future aspirations.

Outside of school, early STEM immersion programs are additional spaces in which students can become initially integrated into the scientific community. A plethora of research supports this assertion and likewise shows that these experiences are crucial to igniting students' interest in science (Betz et al., 2021; Kong et al., 2014; Lehmeidi Dong et al., 2023;

Vesterninen et al., 2016; Young et al., 2017). Such early immersion programs can include summer camps (Prasad et al., 2022; Sowell et al., 2016; Yilmaz et al., 2009), museum visits (Adams et al., 2014; Lavie Alon & Tal, 2015), after-school programs (Chittum et al., 2017; Dabney et al., 2012; Kennedy et al., 2016; Young et al., 2017), or job shadows (Moriarty et al., 2013). Simultaneously, these programs support students' development as engaged citizens. Vesterninen et al. (2016) conducted 35 interviews with 15-19 year old students at a science camp to learn about how they engage in altruism and their views about the role of science in that work. The authors found that students participate in a wide array of activities focused on making the world a better place – these ranged from personally responsible activities (e.g. helping a friend in need, donating to charity) to participatory activities (e.g. mentoring younger students, leading recycling initiatives at school) to career preparatory activities (e.g. studying for a career to help others). These findings demonstrate that students not only desire to engage in community, but they are already involved in doing so before they enter college.

\While students' family and school experiences can positively shape students' STEM aspirations, it is also important to acknowledge the ways in which these influences can adversely affect students. Literature indicates that girls face socialization – both from the microsystem and macrosystem – away from STEM careers due to stereotypes that science (especially natural or hard science) is a masculine pursuit (Archer et al., 2013; Master et al., 2016; Parsons, 1997; Schreiner & Sjoberg, 2007). This conclusion is derived, in part, from the finding that girls demonstrate less overall interest in science despite equal performance in the subject compared to boys (Haworth et al., 2008). Even students as young as age 6 have shown associations of science with masculinity (Hughes, 2001). From a Goal Congruity perspective, these young girls have already manifested incongruence between their gender identity and the pursuit of STEM. For older students, a backlash effect may result from their negative prior experiences with school. Moore III and colleagues (2003) identified the presence of a “prove-them-wrong syndrome” among African American men in engineering, which manifested as a form of resistant capital against detractors during their k-12 years. These motivations continued into students' college years where their Blackness was often under assault in their STEM departments (McGee & Martin, 2011). Similarly, researchers have identified the ways in which Latino students are underserved by their counselors. Students often cited biased treatment and low academic expectations in these experiences (Cavazos Vela et al., 2023; Malott, 2010). Despite such experiences, these students strive to actualize their STEM career and community engagement aspirations.

The Exosystem: Cultural Community Networks

Bronfenbrenner (1979) describes the exosystem to contain individuals' surrounding environments that they may or may not directly interact with yet are nonetheless influenced by. Such influences include the government, media, and extended family. For this chapter, I will highlight the role of students' extended family, or broader cultural networks, in shaping students' STEM community engagement intentions.

Students' extended cultural communities have a profound positive impact on their desire to serve the community through their STEM degree and career, especially for underrepresented minority students in STEM (Espinosa, 2011; Garcia, 2024; Garriott et al., 2017; Herrera & Kovats Sanchez, 2022; Howard et al., 2024; Jaumot-Pascual et al., 2023a, 2023b; Kanagala et al., 2016; Kimmerer, 2013; Madsen et al., 2023; Page-Reeves et al., 2019; Rendon et al., 2020; Smith et al., 2014). Specifically, these students' learned values of reciprocity, community, and collectivism are key motivators for their entrance into and persistence in college STEM programs.

One of the most common themes emerging from the literature is that of students' desire to give back to their community through science. Jaumot-Pascual and colleagues (2023a) define giving back as "engagement in activities that contribute to the empowerment of one's communities and creating positive change" (p. 882). In their work with indigenous students, the authors expanded this definition to include culturally-connected giving back, which refers to "activities where Native individuals contribute to the empowerment of Native communities and to create positive change through the engagement of Native values, cultures, and resources" (p. 883). Biologist and Indigenous scholar Robin Wall Kimmerer and her collection of works (2013; 2024) speak to these cycles of reciprocity between humankind and nature. Black and Latino students also demonstrate aspirations to serve their cultural communities and remain connected to them during college, which can manifest by their choice to attend Historically Black Colleges & Universities (HBCUs) or Hispanic-Serving Institutions (HSIs). Latino students also hold *familismo* – a cultural value centering on family loyalty, dedication, and closeness – in high regard (Calzada et al., 2013; Estrada et al., 2016; Hurtado et al., 2010; Marin & Marin, 1991; Martinez, 2013; Perez II, 2017). In STEM fields, *familismo* can not only serve as a form of familial, navigational, and social capital.

A second emergent theme is that of the importance of students' pre-

college STEM role models, which serve as a mechanism for generating students' positive "figured world of STEM" and thus promoting perceived congruence between their identity and STEM fields. Tan and colleagues (2013) noted that all middle school aged girls interviewed in their study demonstrated familial capital in their science pursuits. One student cited discussions with two close family members who are doctors as important for their science interest. Likewise, students' positive recognition from meaningful others towards their identity as scientists supported their beliefs that "people like them" have opportunities in STEM. This theme continues into students' college years, because altruistically-engaged STEM role models resonate with students and promote their sense of belonging (Fuesting & Diekman, 2017; Gladstone et al., 2024; Gladstone & Cimpian, 2021; Marx & Ko, 2012).

Consequently, students' perceived incongruence between their cultural norms and STEM programs can be a source of conflict (Herrera & Kovats Sanchez, 2022; Page-Reeves et al., 2019; Smith et al., 2014; Tibbetts et al., 2016). Guiffrida and colleagues (2012) write that students of color face additional difficulties ingratiating into predominantly white institutions due to differences between their cultural norm of collectivism (Hofstede & Rowley, 2002; McClellan et al., 2005) and the institutional norm of individualism (Triandis et al., 1998). Even before college, some students may self-select out of the STEM pipeline to avoid these potential value conflicts.

In summary, students' pre-college communal experiences not only shape their STEM interests but also orient themselves towards future community engagement through science. Throughout a wide range of social science literature, we see emergent themes that speak to the benefits of community integration within students' early educational experiences. For example, Rogers et al. (2018) argued that a "collaborative community-focused perspective" (p. 38) is most advantageous for supporting students' needs. Additionally, we see evidence that younger students already have their sights set on community engagement prior to entering college (Vesterninen et al., 2016), and many underrepresented minority students in STEM are driven by community-centered cultural values to pursue careers in STEM (Garcia, 2024; Jaumot-Pascual et al., 2023a; Page-Reeves et al., 2019).

Nourishing Roots: College STEM Experiences

Mentor relationships, peer networks, and high-impact experiences are all forms of STEM students' community engagement during college. These activities serve to nourish the roots with students' communities upon

entering college. This section likewise examines how students engage with micro- and macro-level communities during their college years.

The Microsystem: Mentors, Peers, and High Impact Activities

Faculty and academic mentors are instrumental to STEM students' sense of belonging, self-efficacy, and science identity during college (Baker & Griffin, 2010; Ceyhan & Tillotson, 2020a; Erkut & Mokros, 1984), particularly for first-year students (Fuentes et al., 2014). Supportive mentorship requires that faculty and students make a commitment to continually engage and cultivate an ethic of care (Johnson & Griffin, 2025). For Latino STEM students, a hypercompetitive environment created few instances to cultivate familismo within academic spaces, but interactions that were successful centered on values of trust, reciprocity, and care (Carlone & Johnson, 2007; Lopez et al., 2019). Additionally, mentorship and the creation of counterspaces are areas where Native students enact values of culturally-connected giving back (Jaumot-Pascual et al., 2023a). Native students in STEM see themselves as having a unique capacity to inspire others during their program (Page-Reeves et al., 2019). Native students in the computer science field look to align their scientific endeavors with tribal advancement – citing the role that their computer science knowledge is useful in supporting environmental protection, mental health, and technological sovereignty initiatives on tribal lands (Jaumot-Pascual et al., 2023a). Such opportunities to serve the community were strong motivators to persist in STEM in the face of setbacks. In a similar vein, giving back served as “one of the most fulfilling things” that Native women did during their college years (Powers, 2018, p. iv). These findings echo previous sentiment demonstrating that Indigenous' students persistence in college increases when their education focuses on giving back to the community (Brayboy et al., 2012).

Peer networks also serve as centers of community for college students (Arevalo et al., 2016; Perez II et al., 2018; Watkins & Mensah, 2019). In one peer mentoring program at Arizona State University, peer mentors served dual roles for students as academic guides (i.e. sharing key information) and psychological supports (i.e. a caring friend), which demonstrates peers' roles as sources of navigational and social capital (Yosso, 2005; Zaniewski & Reinholz, 2016). From the academic angle, Salomone and Kling (2017) explored the effects of peer-led learning sessions across five introductory STEM courses. Students who attended these sessions not only had higher course grades than previous students, but also maintained higher retention rates in their programs two years later. It is crucial to

support STEM students' social networks as they are important retention mechanisms (Ceyhan et al., 2019; Damkaci et al., 2017; Gatz et al., 2018; Salomone & Kling, 2017; Turetsky et al., 2020; Zwolak et al., 2017), because they act as “sticky webs” that ingratiate and encourage students to persist through challenging academic environments (Moynihan & Pandey, 2008). When students position themselves centrally within the figurative “web”, they are much more likely to persist in STEM. For example, Zwolak and colleagues (2017) used network analysis to study students' positioning within an introductory physics class. The authors found that students at the center of the classroom peer network had a higher rate of persistence in later physics courses. For women and girls in STEM, supportive peers foster feelings of belonging that help them counteract the effects of exposure to sexist messages (Leaper, 2015). Similarly, Revelo Alonso (2015) and Revelo and Baber (2018) found that engineering students cultivated resistant and social capital through peer-led professional organizations.

I have just discussed who STEM students engage in community with during their college experiences. But, where and how does this engagement take place? It is here that we can turn to high-impact STEM practices (Ives et al., 2024; Kuh, 2008; Pendakur et al., 2020; Peters et al., 2019). These practices refer to activities that have been repeatedly shown to increase student learning, retention, and engagement within STEM programs and institutions overall (Kilgo et al., 2015). These practices include undergraduate research experiences, studying abroad, first-year seminar courses, service learning, and living learning communities. While all are valuable, undergraduate research and service learning are the most directly applicable to discussions of STEM students' community engagement. First, students' participation in undergraduate research and service learning both facilitate their entry into scientific communities of practice (Lave & Wenger, 1991). It is in these environments that students learn key skills – such as critical thinking, experimental design, and data analysis – needed to be successful in science (Ceyhan & Tillotson, 2020b; Seifan et al., 2022). And second, these environments socialize students into a collaborative environment, which reinforces the notion that science is a community endeavor (Saavedra et al., 2022; Vesterinen et al., 2016). Nalipay and colleagues (2024) expanded this line of research by finding that students' sense of empathy cultivated during a service learning course also had downstream effects on their citizenship attitudes and STEM persistence intentions. This interesting finding demonstrates that cultivating students' knowledge of community can support learning and also promote social betterment.

In all of these forms of engagement, students seek congruence between their STEM activities and community service ambitions (Garcia, 2024; Herrera & Kovats Sanchez, 2022; Nalipay et al., 2024; Reyes et al., 2024; Saavedra et al., 2022; Thoman et al., 2015; Vasquez-Salgado et al., 2015). This is especially true for students of color. In their seminal work, *The Equity Ethic*, McGee and Bentley (2017) explore how high-achieving Black and Latino students' STEM aspirations are grounded in a concern for helping others. In a series of interviews with medical students, Antony (1996) identified that one of the key motivating factors for students pursuing medical school was a desire to serve the public. For Latino premedical students, "giving back" to address health disparities was a cultural asset that led to degree completion in four distinct ways – employing Spanish language skills within medicine, volunteering during college within communities, creating infrastructure for future premedical students at the institution, and desiring to practice medicine within underserved communities in the future (Garcia, 2024). Similarly, ethnic minority research assistants in STEM who see the altruistic value in their research feel more psychologically connected to their work and, in turn, more engaged with it (Thoman et al., 2015). Lastly, Yu and colleagues (2025) found that sense of belonging mediates the relationship between STEM students' feelings of goal congruity and persistence.

Challenging the Institutional Macrosystem

Despite these positive motivating influences described above, it is important to acknowledge reasons why students may not be able to fully participate in these community-building initiatives, and how institutional macrosystems might hinder their participation. During college, URM students face conflicts between their social justice intentions and the future demands of a competitive STEM career (Herrera & Kovats Sanchez, 2022; Tran, 2011; Tran et al., 2011). All interviewed participants in Herrera and Kovat Sanchez's (2022) study noted a lack of social-justice oriented role models in their STEM programs. Underrepresented students of color in STEM even report compartmentalizing their social and academic identities from their science identities (McCoy et al., 2015).

Administrative efforts to improve retention for students from underrepresented groups can also differ drastically from students' desires and needs (Guillory & Wolverton, 2008; Luedke, 2017; Page-Reeves et al., 2019; Smith et al., 2014). Guillory & Wolverton (2008) highlighted these differences in regard to Native college students. They found that administrators focused retention efforts on greater financial aid for students. While financial support is undoubtedly important in helping students

persist, students also spoke about a further desire to have their college connect with tribal communities. Latino students may experience conflict between institutional norms and familismo. As Frederick and colleagues (2023) explained, the collectivist core of familismo is incongruent with dominant higher education paradigms that reward individualistic pursuits and assume that students prefer separation from family during college. Ultimately, these examples reflect what Vasquez-Salgado and colleagues (2015) deem “home-school value conflicts” or “home-school cultural value mismatch”. These norms can also manifest through outright racism, which forces students to exhibit resistant capital. For example, one student in McGee and Bentley’s (2017) study – Eduardo – was advised to “stop hanging out with friends from his hometown” and “to tone down his accent” (p. 1646). Institutions and STEM departments cement structural racism when their programs work to “fix” or “assimilate” underrepresented students of color into dominant (i.e. White male) paradigms while ignoring their role in perpetuating racism therein (Johnson et al., 2011; McGee, 2020).

A third hindrance is that students may not be able to afford to take unpaid internships or research experiences during their college experience – roles that produce the “invisible labor” of institutions (Hart, 2014; Steffen, 2010). To compound this challenge, undergraduate students are increasingly older, raising families, and are more likely to be low-income (Cote, 2023; Purdy, 2021). Many institutions have recognized the socioeconomic barrier that students face to these activities and have attempted to alleviate the burden by providing stipends to participating students, but this is not the norm (Guessous et al., 2015; Schmidt et al., 2003). Additionally, the structure of advanced scientific training (e.g. REU programs) can push students out of the STEM pipeline if they are unable to commit to a potential out-of-state program lasting several months. Given that low-income and first-generation college students are more likely to attend college closer to home, these programs may not be attainable or desirable for these students. Furthermore, an increasing number of students are electing to live at home for college (UCAS, 2000) – a trend that some scholars say hinders academic socialization (Garza & Fullerton, 2018), but I would argue rather reflects students’ community cultural wealth that support their success (Patiniotis & Holdsworth, 2005; Yosso, 2005). But, while these students may not be engaged in traditional high-impact activities, STEM programs should recognize the valuable skills that these students are mastering within their various roles. For example, students likewise learn discipline and time management skills – just like they would in a research laboratory setting – from holding down a paid off-campus job or raising a family while

simultaneously attending college classes. Therefore, we should expand our collective notion of what constitutes a high-impact experience so that we can recognize how diverse students are championing STEM success and community engagement beyond what the literature suggests.

Putting Down Roots: Post-College STEM Experiences

Not only do STEM students maintain aspirational capital towards community engagement prior to and during college, but they also contribute to their scientific and social communities in many ways after their undergraduate STEM education concludes. The literature shows that early career scientists enter their professions with a desire to serve others and cultivate community within such spaces (Carrigan 2017; Gibbs Jr. & Griffin, 2017; Litchfield & Javernick-Will, 2015; Villarejo et al, 2008). A survey of recent URM STEM graduates identified attributes that would make research careers more attractive (Villarejo et al., 2008). The attribute, “knowing that scientific knowledge they created would help members of the community”, was the second-most positively rated attribute of those provided. Additionally, surveyed alumni that left research frequently cited their desire to serve others in a more direct way in their career. Gibbs Jr. and Griffin (2017) more recently interviewed 38 early career science PhDs and found that many who pursued the academic faculty career path shared a passion for engaging with others. Many participants cited a goal to create community within their academic department, even if their college experiences lacked such connections. For example, one participant – Alicia – pursued an academic career for communal ends, stating, “It’s rewarding to think about being able to mentor students. That’s really what I’m passionate about.” (p. 718). These sentiments contrast sharply with her own engineering experiences in which a male colleague advocated against hiring a female student due to his belief that “women can’t do math and they’re not really competent in mathematics.” (p. 717). Alicia’s persistence in STEM exemplifies her resistant capital.

STEM students’ familial capital is another hallmark of their post-college experiences. McAlpine and colleagues’ (2014) longitudinal study of graduate scholars and early career professionals revealed the extent to which students’ families remain core to their professional journeys. These individuals were at various stages of their lives, but all of whom were “putting down roots” in their respective communities. Scientists must navigate the balance between their professional and personal lives, which many cited as a challenge during their doctoral studies and early careers.

Early career scientists frequently engage with their communities to disseminate the knowledge they gained as college students and serve as mentors for younger students. Many Native American college graduates in fact view it as their responsibility to give back to the communities after college (Guillory, 2008; Jaumot-Pascual et al., 2023a, 2023b; Salis Reyes, 2019). These students use the skills they developed in college as foundation to serve their communities in tangible ways, with many efforts dedicated to ensuring tribal sovereignty and prosperity (Brayboy et al., 2012; Jaumot-Pascual et al., 2023a, 2023b; Salis Reyes, 2019). Native American STEM graduates act as “trusted insiders” who can “translate scientific concepts to make them more meaningful for people in the community who do not have scientific training or who might not understand the issues.” (Page-Reeves et al., 2019, p 27).

Recently, Wierenga and colleagues (2025) proposed the concept of communities for impact as “spaces to help researchers (especially early-career researchers) cope with the challenges of impact-driven research” (p. 19). Many early career researchers are passionate about high-impact interdisciplinary research that can serve communities and assist in solving global challenges, yet there are institutional barriers in academia that hinder this work (Ferraro et al., 2015; Wierenga et al., 2025). These barriers can include the tenure promotion pipeline, department-specific research funding, and the reality that these issues (such as climate change) could be construed as divisive in this current higher education landscape. The scope and complexity of impact-driven research requires extensive analysis and collaboration that results in fewer publications – a barrier especially challenging for untenured researchers. Communities for impact help empower impact-driven researchers through peer support, networking, and strategizing about their projects. The communities possess the threefold goals of creating community among passionate researchers, legitimizing community-driven research in academia, and alleviating tension between their career advancement and research pursuits (Baudoin et al., 2023; Trinh et al., 2022; Wierenga et al., 2025). These groups can serve as a model for how STEM educators and researchers can build communities that allow students’ community engagement pursuits to be recognized and supported both during and after their college years.

Practices for Growth

We can work to advance community engagement within STEM education. These five recommendations center around making communal goals within STEM fields more salient and providing additional opportunities for students

to work and learn in community (Boucher et al., 2017; Fuesting & Diekman, 2017; Herrera & Kovats Sanchez, 2022; Joshi et al., 2022; Rendon et al., 2020). Following Bronfenbrenner's (1979, 1994) approach, I first address microsystem-level recommendations and then proceed to discuss beneficial practices at mesosystem and exosystem level. These five recommendations are 1. Celebrate students' communities and cultural backgrounds; 2. Center instruction on how science can address social injustices; 3. Embed communal goals and opportunities within STEM curricula; 4. Leverage learning opportunities of place-based education; and 5. Embrace the promises of citizen science.

Celebrate Students' Communities and Cultural Backgrounds

The first recommendation calls for us to celebrate STEM students' communities and cultural backgrounds. Students bring to STEM departments a wealth of knowledge, resources, and connections to their communities. According to Mwangi and colleagues (2021), there is little literature exploring how STEM students navigate family and school, or how STEM programs affect students' relationships with home. The authors found that many of the participating STEM students' departments "did not build meaningful engagement opportunities within local communities that acknowledge students' motivations for pursuing STEM degrees" (p. 1). Using Yosso's (2005) CCW framework as a guide, educators should celebrate students' cultural backgrounds as an asset that students bring to STEM programs rather than as baggage that holds them back from STEM success (Burt & Johnson, 2018; Denton et al., 2020; Rincon et al., 2020; Rincon & Rodriguez, 2021; Samuelson & Litzler, 2016).

STEM departments can utilize several strategies to achieve this goal. First, departments should recognize the forms of capital that students bring to STEM spaces. For example, Cochran et al. (2025) recently examined physics graduate students' familial capital in order to provide guidance for physics graduate programs. Given that many students cited critical support from family during their programs, the authors recommended that graduate programs structure more opportunities for families to be involved in celebrating students' key milestones such as orientation, passage of comprehensive exams, and department graduations. On the note of celebration, departments can also recognize culturally significant holidays for students and disseminate information about wider campus events that connect to students' cultural backgrounds. Partnerships with student organizations – such as the Association for Women in Science (AWIS) and

the National Society of Black Engineers (NSBE) – could likewise be valuable for STEM departments. In short, STEM students should be invited to share about their familial and cultural experiences. We can also center students' aspirational capital in STEM. Upon students' entrance to a STEM program and throughout, faculty should inquire about their motivations for pursuing STEM and seek alignment between course objectives and achieving these goals. Using a culturally responsive approach, instructors can tailor certain aspects of the curriculum to address students' goals.

Center Instruction on How Science Can Address Social Injustices

One of the most persistent misconceptions about the nature of science is that it operates in a vacuum – isolated from social influence and not able to serve broader societal goals (Chalmers, 1976; McComas, 2002; Rubba, 1981). Within STEM curricula, we can center instruction on how science can address social injustices. This recommendation attends to students' desire to advance equity and justice through their science careers and thus improve their perceived congruity between their social justice intentions and future careers (Brown et al., 2015; Diekman et al., 2010; Isenegger et al., 2023; McGee, 2016; McGee & Bentley, 2017; Steinberg & Diekman, 2017).

There are many relevant case studies that STEM educators can embed within their teaching to show students how science can advance social justice aims. For example, the Next Generation Science Standards (2013) outlined a core objective for biology students including HS-LS3: inheritance and variation of traits. In meeting this objective, biology educators might consider a case study of the Human Genome Project – a historic international research effort that resulted in the full sequencing of the human genome and opened the door for more targeted medical treatments. Students can learn about how geneticists and doctors partnered to advance treatments towards sickle cell disease, which remains a debilitating blood disease overrepresented in African American and Hispanic communities (Pace, 2007). Students can also reckon with the reality that these scientific treatments were developed in a context of persistent stigma of the disease in the American public (Bulgin et al., 2018) and discuss how such dynamics would affect the scientific community.

Likewise, a chemistry course could incorporate a case study of the ongoing lead pipe crisis in urban centers during discussion of chemical bonding and aqueous chemistry. Instructors can center the ongoing fight for environmental justice in Flint, Michigan – a municipality outside of

Detroit, USA whose residents have long suffered with high levels of lead in their water as a result of a government decision to switch the local water source to the Flint River without corrosion inhibitors (Campbell et al., 2016). Physics and engineering students can learn principles of community-oriented engineering pedagogy (Rayna, 2022). This pedagogy centers equity and justice in engineering outcomes. Students can not only embed these principles into their future engineering practice but also understand how engineering projects of the past may have not lived up to these ideals. In another example, my hometown of Syracuse, New York is undergoing demolition of Interstate-81 – a substantial elevated highway completed in 1969 that resulted in the destruction of the thriving 15th Ward and served as a dividing line between Black communities and the wealthier urban areas (Teron, 2022). The interstate was a fixture of inequality in the city for decades. In recent years, engineers, officials, and residents have come together to plan removal of the elevated highway in favor of a more equitable community grid plan.

In all these examples, scientists have been key stakeholders advocating for broader communities. STEM disciplines are positioned as pathways through which scientists serve humanity (McGee & Bentley, 2017). Students will develop an understanding of how they capitalize on their social justice intentions through science while maintaining rigorous scientific standards. From a goal congruence perspective, students also learn that there is overlap – and indeed, congruence – between their socially active “selves” and scientific “selves” (Markus & Nurius, 1986). These efforts are likely to have positive downstream effects on students’ interest and retention in STEM (Belanger et al., 2020; Carter et al., 2021; Isenegger et al., 2023; Yu et al., 2025).

Embed Communal Goals and Opportunities within STEM Curricula

The third recommendation calls on STEM departments to make salient the communal goals and opportunities within STEM. The literature shows that students are more likely to persist in STEM if they perceive these disciplines to be collaborative and communal in nature (Diekman et al., 2010; Steinberg & Diekman, 2017). Interestingly, Joshi and colleagues (2022) found that life science departments showcased greater community opportunities for students as compared to natural science departments. The authors found that physics and engineering departments tended to have fewer collaborative assignments or community events advertised within shared department spaces. Thus, all STEM departments – but especially

those in the natural sciences – should support initiatives to foster community among students and faculty.

Inside the classroom, collaborative work can be a cornerstone of STEM learning. The scholarship portfolio of mathematician and mathematics educator Dr. Uri Treisman can serve as a guide for fully embedding collaboration within STEM learning. As a doctoral student, Treisman identified that many undergraduate STEM students, particularly those from underrepresented minority communities, struggle in mathematics despite their numerous successes outside the classroom. The existing literature at the time framed these students' struggles as a result of their lack of motivation or family emphasis on education (Triesman, 1992). However, he observed that URM students – especially immigrant students – formed informal social communities to support their learning. In response to his observations and existing literature, Triesman launched the Emerging Scholars Program (ESP) as a way to not only promote camaraderie among students but instill rigorous STEM learning from an asset-based perspective – much like Yosso (2005) would later offer with the CCW framework. At their core, ESPs see students work collaboratively to solve challenging problems in an active learning environment (Fullilove & Treisman, 1990; Treisman, 1992). Peers and instructors embrace their role as facilitators during this process. Treisman's program has been repeatedly shown to improve both URM and non-URM students' performance and persistence in STEM fields at various institutions (Deshler et al., 2016; Hsu et al., 2008; Jamieson et al., 2012; Johnson & Elliott, 2020; Miller et al., 2021). At West Virginia University, 81% of URM students passed an ESP calculus course compared to 50% who passed in a non-ESP calculus course (Miller et al., 2021). These findings indicate that communal STEM learning can advance students' achievement while also supporting their social, aspirational, and navigational capital.

Another viable strategy to improve students' communal perceptions of STEM fields is through exposure to altruistic or community-engaged scientific role models. Morgenroth and colleagues' (2015) Motivational Theory of Role Modeling offers a framework for understanding how role models positively impact students. The scholars put forth three core role model attributes that have such effects on students: perceived similarity to the student, embodiment of success and competence, and achievement of attainable success. Such role models serve to inspire students that they can likewise achieve success, and both observational and experimental research have shown that students perceive higher levels of similarity with scientific

role models that work with the public or value altruistic goals (Gladstone & Cimpian, 2021; Marx & Ko, 2012). In STEM curricula, students can learn from these role models in numerous ways such as scientist spotlight assignments (Brandt et al., 2020; Metzger et al., 2023), guest speakers (Casper & Balgopal, 2020), and field trips (Jones & Washko, 2022).

We should not only encourage students to engage with the community outside the classroom, but also eliminate barriers to make it possible for students to participate. Murphy and Kelp (2023) find that STEM students are motivated to pursue community engagement but often lack opportunities to do so. The authors recommend that STEM departments make concerted efforts to engage students with community through interventions such as course-based undergraduate research experiences (CUREs) or k-12 science outreach. To facilitate widespread student participation in such initiatives, departments may consider offering college credit or a stipend for students so that they can financially justify participation. Institutional partnerships with industry, local k-12 schools, and nonprofit organizations will be invaluable to these efforts.

Through these interventions, students can “disrupt stereotypic perception that STEM fields do not provide communal opportunities and foster positivity towards them” (Brown et al., 2018, p. 12). These efforts prompt students’ experiences of congruence between their desired communal goals and their STEM education. From a CCW perspective, student engagement in these opportunities outlined above nurtures various forms of capital both in students and faculty.

Leverage Learning Opportunities of Place-Based Education

Place-based education (PBE) refers to the sentiment that education should be rooted in the locations and communities in which they exist, which Deringer (2017) analogizes as community “not stopping at the walls of the schoolhouse” (p. 335) and instead addressing local problems through education (Gruenewald, 2003). PBE is inherently interdisciplinary and acknowledges the various meanings that place has for students, teachers, and community members (Demarest, 2014; Dunbar-Wallis et al., 2024). The advantages of PBE are threefold. The approach promotes synergy between STEM students and their surroundings, which in turn causes students to consider both the unique experiences of living and studying within a place, as well as the potential similarities across cultures and communities (Habig & Gupta, 2021; Raja, 2024). Second, PBE engages STEM students in solving community problems – efforts which tangibly improve the lives of the

citizens within. Third, PBE works to decolonize STEM education by centering Indigenous perspectives or “ways of knowing” (Kimmerer, 2013, 2024; O’Neill et al., 2023). Syracuse University – my home institution – maintains ongoing initiatives that support the latter two goals of PBE. Specifically, we are home to the Engaged Humanities Network, a scholarly collective dedicated to advancing community-engaged research within Central New York. One active project is the Food Sovereignty and Seed Rematriation project, led by Dr. Mariaelena Huambachano, whose purpose is to reclaim indigenous food knowledge advanced by the native Onondaga people living in the region. Projects such as these are important to advance STEM students’ sense of place as well as expand their understanding of the diversity that scientific research and community engagement projects can take on.

Embrace the Promises of Citizen Science

To fully capitalize on the benefits of community engagement in science, institutions need to facilitate easy and widespread opportunities for community members to engage in the scientific process. As Bronfenbrenner (1979) would suggest, we can work to expand scientific enterprise from an activity within the microsystem to the exosystem of the institution. By doing so, we not only produce greater scientific knowledge (Cohn, 2008; Delaney et al., 2008; Elbroch et al., 2011) but also work to combat the stereotype that science remains an isolated pursuit (Diekman et al., 2010; Nicholls et al., 2007).

Like PBE, citizen science holds tremendous promise in bridging gaps between professional science, STEM education, and the public. Broadly defined, citizen science projects see volunteers partner with professional scientists to answer real-world questions (Citizen Science Central, 2013). The project sponsor – usually a university department or nonprofit – specially designs such projects to give a role to community members. Such roles can range from data collection to data analysis to presentation of results. One of the most prominent ongoing citizen science projects is facilitated by the USGS National Institute of Invasive Species Science (Gallo & Waitt, 2011; Pocock et al., 2024; Silvertown, 2009). Citizens nationwide partner with the Institute to document the presence of invasive species in their local communities, which provides crucial knowledge necessary for their early eradication. Similarly, a recent citizen science project documented 141 native species within US National Parks that had not been previously recorded by the National Park Service (Katzer et al., 2025). Quality citizen science projects are able to maximize the contributions of both the volunteers and professionals, which ultimately work in tandem to advance project aims

(Silvertown, 2009).

Students, higher education institutions, and scientists alike would all benefit from heightened participation in citizen science initiatives. First, students stand to gain significant benefits from citizen science initiatives. Numerous studies indicate that students experience gains in science knowledge (Kermish-Allen et al., 2019), scientific reasoning (Rogele, 2021), science interest (Smith et al., 2021), and civic engagement behaviors (Condon & Wichowsky, 2018) as a result of participation. Second, citizen science represents an open frontier for institutions. By partnering with the public, institutions expand their reach to new communities, which is likely to have positive downstream effects on their quantity of applications, support for future institutional initiatives and participation within, and overall community standing (Dick, 2017). Third, scientists themselves acknowledge the untapped potential of citizen science. Burgess and colleagues (2017) reported that 78% of their scientists surveyed said that their data could be collected by amateurs but only 34% have previously employed citizen scientists. While some scientists believe citizen science data poses validity concerns, this concern can be allayed in light of recent findings (Katzner et al., 2025; Riesch & Potter, 2014). Cohn (2008) examined a McGill University study of New England invasive crab species and found that participating 7th graders possessed a 95% correct observation rate. Additionally, citizen science represents greater democratic participation in the scientific enterprise – challenging the notion that the boundary between science and society is a “semipermeable membrane, through which knowledge only flows outward” (Ziman, 1984, p. 4). In this deficit paradigm, citizens are expected to be informed about scientific developments but also recognize that they do have the expertise to comment on complex decisionmaking (Levison, 2010; Wynne et al., 1995). Rather, a science education as praxis approach sees science as emergent knowledge whose generation deconstructs boundaries between expert and lay knowledge (Levinson, 2010). Participants work towards a common goal, and the status of citizens are elevated to that of citizen scientists or “scientists-in-training”. Not only does citizen science promote egalitarian values within science, but it expands the definition of science community to involve all those who engage with science, not just credentialed experts.

Conclusion

This chapter has explored the myriads of ways in which STEM students foster, experience, and redefine community engagement in science. Three theoretical frameworks – Ecological Systems Theory (Bronfenbrenner, 1979, 1994), Goal Congruity Framework (Diekman et al., 2010) and Community

Cultural Wealth (Yosso, 2005) – have demonstrated utility in this pursuit. We see that students’ supportive pre-college experiences with family, teachers, and cultural groups establish their “roots” as members of their community. Students’ academic and social relationships, coupled with their participation in high-impact science practices, nourish their altruistic STEM career ambitions during college. After college, students emerge as newly-trained scientists ready and able to give back to the community. These empirical findings led me to offer five practices for growth for researchers and educators looking to capitalize on what Brown and colleagues (2018) deem this “new vantage point” for STEM education (p. 21). Following Bronfenbrenner’s (1979) approach, these recommendations center different systems (and therefore different units of analysis) to celebrate and leverage the opportunities for community engagement in STEM education. Researchers, educators, students, and citizens alike can collaborate to fully capitalize on the potential for STEM community engagement.

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References

- Adams, J. D., Gupta, P., & Cotumaccio, A. (2014). Long-Term Participants: A Museum Program Enhances Girls' STEM Interest, Motivation, and Persistence. *Afterschool Matters*, 20, 13-20.
- Allen, J. M., Muragishi, G. A., Smith, J. L., Thoman, D. B., & Brown, E. R. (2015). To Grab and to Hold: Cultivating Communal Goals to Overcome Cultural and Structural Barriers in First-Generation College Students' Science Interest. *Translational Issues in Psychological Science*, 1(4), 331-341. <https://doi.org/10.1037/tps0000046>
- American School Counselor Association (ASCA). (2022). *ASCA ethical standards for school counselors*. Author.
- Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, 21(1), 171-194. <https://doi.org/10.1080/14681366.2012.748676>
- Arevalo, I., So, D., & McNaughton-Cassill, M. (2016). The role of collectivism among Latino American college students. *Journal of Latinos and Education*, 15(1), 3-11. <https://doi.org/10.1080/15348431.2015.1045143>
- Baudoin, L., Carmine, S., Nava, L., Poggioli, N., & Broek, O. M. (2023). Imagining a Place for Sustainability Management: An Early Career Call for Action. *Journal of Management Studies*, 60(3), 754-760. <https://doi.org/10.1111/joms.12887>
- Baker, V. L., & Griffin, K. A. (2010). Beyond mentoring and advising: Toward understanding the role of faculty "developers" in student success. *About Campus*, 14(6), 2-8. <https://doi.org/10.1002/abc.20002>
- Beaton, A. E., Martin, M. O., Mullis, I. V., Gonzalez, E. I., Smith, T. A., & Kelly, D. L. (1998). Create News; Consortium for Research on Educational Accountability and Teacher Evaluation; Mathematics and Science Achievement in the Middle School Years: An International Perspective. *Journal of Personnel Evaluation in Education*, 12(1), 69. <https://doi.org/10.1023/A:1007968617286>
- Beckwith, J., & Huang, F. (2005). Should we make a fuss? A case for social responsibility in science. *Nature Biotechnology*, 23(12), 1479-1480. <https://doi.org/10.1038/nbt1205-1479>
- Belanger, A. L., Joshi, M. P., Fuesting, M. A., Weisgram, E. S., Claypool, H. M., & Diekman, A. B. (2020). Putting Belonging in Context: Communal Affordances Signal Belonging in STEM. *Personality & Social Psychology Bulletin*, 46(8), 1186-1204. <https://doi.org/10.1177/0146167219897181>

Betz, A. R., King, B., Grauer, B., Montelone, B., Wiley, Z., & Thurston, L. (2021). Improving Academic Self-Concept and STEM Identity Through a Research Immersion: Pathways to STEM Summer Program. *Frontiers in Education (Lausanne)*, 6. <https://doi.org/10.3389/educ.2021.674817>

Boucher, K. L., Fuesting, M. A., Diekman, A. B., & Murphy, M. C. (2017). Can I Work with and Help Others in This Field? How Communal Goals Influence Interest and Participation in STEM Fields. *Frontiers in Psychology*, 8, 901. <https://doi.org/10.3389/fpsyg.2017.00901>

Bourdieu, P., & Passeron, J. C. (1977). *Reproduction in education, society and culture*. Sage Publications.

Brandt, S., Cotner, S., Koth, Z., & McGaugh, S. (2020). Scientist Spotlights: Online assignments to promote inclusion in Ecology and Evolution. *Ecology and Evolution*, 10(22), 12450–12456. <https://doi.org/10.1002/ece3.6849>

Branje, S., de Moor, E. L., Spitzer, J., & Becht, A. I. (2021). Dynamics of Identity Development in Adolescence: A Decade in Review. *Journal of Research on Adolescence*, 31(4), 908–927. <https://doi.org/10.1111/jora.12678>

Brayboy, B. M. J., Fann, A. J., Castagno, A. E., & Solyom, J. A. (2012). *Postsecondary education for American Indian and Alaska Natives: Higher education for nation building and self-determination: ASHE Higher Education Report 37: 5* (Vol. 37, No. 5). John Wiley & Sons.

Bronfenbrenner, U. (1979). *Ecology of human development: experiments by nature and design* (1st ed.). Harvard University Press. <https://doi.org/10.2307/j.ctv26071r6>

Bronfenbrenner, U. (1994). Ecological models of human development. *International encyclopedia of education*, 3(2), 37-43.

Brown, B. A., & Kelly, G. J. (2007). Language, Identity, and the Appropriation of Science Discourse. *Science, learning, identity: Sociocultural and cultural-historical perspectives*, 7, 283.

Brown, E. R., Steinberg, M., Lu, Y., & Diekman, A. B. (2018). Is the Lone Scientist an American Dream? Perceived Communal Opportunities in STEM Offer a Pathway to Closing U.S.–Asia Gaps in Interest and Positivity. *Social Psychological & Personality Science*, 9(1), 11–23. <https://doi.org/10.1177/1948550617703173>

Brown, E. R., Thoman, D. B., Smith, J. L., & Diekman, A. B. (2015). Closing the communal gap: The importance of communal affordances in science career motivation. *Journal of Applied Social Psychology*, 45(12), 662–673. <https://doi.org/10.1111/jasp.12327>

Bulgin, D., Tanabe, P., & Jenerette, C. (2018). Stigma of Sickle Cell Disease: A Systematic Review. *Issues in Mental Health Nursing*, 39(8), 675–686. <https://doi.org/10.1080/01612840.2018.1443530>

Burgess, H. K., DeBey, L. B., Froehlich, H. E., Schmidt, N., Theobald, E. J., Ettinger, A. K., HilleRisLambers, J., Tewksbury, J., & Parrish, J. K. (2017). The science of citizen science: Exploring barriers to use as a primary research tool. *Biological Conservation*, 208, 113–120. <https://doi.org/10.1016/j.biocon.2016.05.014>

Burt, B. A., & Johnson, J. T. (2018). Origins of early STEM interest for Black male graduate students in engineering: A community cultural wealth perspective. *School Science and Mathematics*, 118(6), 257–270. <https://doi.org/10.1111/ssm.12294>

Calzada, E. J., Tamis-LeMonda, C. S., & Yoshikawa, H. (2013). Familismo in Mexican and Dominican Families From Low-Income, Urban Communities. *Journal of Family Issues*, 34(12), 1696–1724. <https://doi.org/10.1177/0192513X12460218>

Campbell, C., Greenberg, R., Mankikar, D., & Ross, R. (2016). A Case Study of Environmental Injustice: The Failure in Flint. *International Journal of Environmental Research and Public Health*, 13(10), 951–1. <https://doi.org/10.3390/ijerph13100951>

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218. <https://doi.org/10.1002/tea.20237>

Carlsson, J. (2015). *Evolving identities: Contents and processes of identity development among people in their late twenties*.

Carlsson, J., Wängqvist, M., & Frisén, A. (2015). Identity Development in the Late Twenties: A Never Ending Story. *Developmental Psychology*, 51(3), 334–345. <https://doi.org/10.1037/a0038745>

Carrigan, C. M. (2017). Yearning to Give Back: Searching for Social Purpose in Computer Science and Engineering. *Frontiers in Psychology*, 8, 1178. <https://doi.org/10.3389/fpsyg.2017.01178>

Carter, S. C., Griffith, E. M., Jorgensen, T. A., Coifman, K. G., & Griffith, W. A. (2021). Highlighting altruism in geoscience careers aligns with diverse US student ideals better than emphasizing working outdoors. *Communications Earth & Environment*, 2(1), Article 213. <https://doi.org/10.1038/s43247-021-00287-4>

Casper, A. M. A., & Balgopal, M. M. (2020). How guest experts tell stories about environmental socio-scientific issues in an undergraduate class. *International Journal of Science Education*, 42(9), 1568–1584. <https://doi.org/10.1080/09500693.2020.1772519>

Cavazos Vela, J., Guerra, F., Zamora, E., & Perez, E. (2023). Exploring Latinx College Students' Experiences With High School Counselors. *Professional School Counseling*, 27(1). <https://doi.org/10.1177/2156759X231163525>

Ceyhan, G. D., Thompson, A. N., Sloane, J. D., Wiles, J. R., & Tillotson, J. W. (2019). The Socialization and Retention of Low-Income College Students: The Impact of a Wrap-Around Intervention. *International Journal of Higher Education*, 8(6), 249–261. <https://doi.org/10.5430/ijhe.v8n6p249>

Ceyhan, G. D., & Tillotson, J. W. (2020). Mentoring structures and the types of support provided to early-year undergraduate researchers. *CBE—Life Sciences Education*, 19(3), ar26. <https://doi.org/10.1187/cbe.19-09-0183>

Ceyhan, G. D., & Tillotson, J. W. (2020). Early year undergraduate researchers' reflections on the values and perceived costs of their research experience. *International Journal of STEM Education*, 7(1), Article 54. <https://doi.org/10.1186/s40594-020-00248-x>

Chalmers, A. (1976). *What is this thing called science?* University of Queensland Press.

Chavez, R. D. (2024). *Linguistic Servingness: Experiences of Designated Bilingual Staff and Supervisors at an Emerging Hispanic Serving Institution*. ProQuest Dissertations & Theses.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, 6, 49. <https://doi.org/10.3389/fpsyg.2015.00049>

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, Á. B. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education*, 4(1), Article 11. <https://doi.org/10.1186/s40594-017-0065-4>

Chiu, T. K. F., Ismailov, M., Zhou, X., Xia, Q., Au, C. K., & Chai, C. S. (2023). Using Self-Determination Theory to Explain How Community-Based Learning Fosters Student Interest and Identity in Integrated STEM Education. *International Journal of Science and Mathematics Education*, 21(Suppl 1), 109–130. <https://doi.org/10.1007/s10763-023-10382-x>

Citizen Science Central (2013) *Defining citizen science*. Available at

(accessed 22 May 2013): www.birds.cornell.edu/citscitoolkit/about/definition/

Clark, E. K., Fuesting, M. A., & Diekman, A. B. (2016). Enhancing interest in science: exemplars as cues to communal affordances of science. *Journal of Applied Social Psychology*, 46(11), 641–654. <https://doi.org/10.1111/jasp.12392>

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of developmental research. *Educational Psychologist*, 31(3), 175–190. https://doi.org/10.1207/s15326985ep3103&4_3

Cochran, G. L., Ptak, C., Tempkin, J., Boone, T., Nelson, S. F., Henige, S. R., & Sachmpazidi, D. (2025). Understanding familial capital and its implications for physics graduate programs. *Physical Review. Physics Education Research*, 21(2), Article 020116. <https://doi.org/10.1103/j9ry-jqp4>

Cohn, J. P. (2008). Citizen Science: Can Volunteers Do Real Research? *Bioscience*, 58(3), 192–197. <https://doi.org/10.1641/B580303>

Comer, J. P. (1988). Educating Poor Minority Children: Schools must win the support of parents and learn to respond flexibly and creatively to students' needs. A successful program developed in New Haven points the way. *Scientific American*, 259(5), 42. <https://doi.org/10.1038/scientificamerican1188-42>

Condon, M., & Wichowsky, A. (2018). Developing citizen-scientists: Effects of an inquiry-based science curriculum on STEM and civic engagement. *The Elementary School Journal*, 119(2), 196–222. <https://doi.org/10.1086/700316>

Coté, L. E. (2023). Making the case for paying undergraduate researchers in STEM disciplines. *Volume 1 (2023)*.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-School Time Science Activities and Their Association with Career Interest in STEM. *International Journal of Science Education. Part B. Communication and Public Engagement*, 2(1), 63–79. <https://doi.org/10.1080/21548455.2011.629455>

Damkaci, F., Braun, T. F., & Gublo, K. (2017). Peer Mentor Program for the General Chemistry Laboratory Designed To Improve Undergraduate STEM Retention. *Journal of Chemical Education*, 94(12), 1873–1880. <https://doi.org/10.1021/acs.jchemed.7b00340>

Delaney, D. G., Sperling, C. D., Adams, C. S., & Leung, B. (2008). Marine

invasive species: validation of citizen science and implications for national monitoring networks. *Biological Invasions*, 10(1), 117–128. <https://doi.org/10.1007/s10530-007-9114-0>

Delgado Bernal, D. D. (2001). Learning and living pedagogies of the home: The mestiza consciousness of Chicana students. *International Journal of Qualitative Studies in Education*, 14(5), 623–639. <https://doi.org/10.1080/09518390110059838>

Demarest, A. B. (2014). *Place-based Curriculum Design: Exceeding Standards through Local Investigations* (1st ed.). Routledge. <https://doi.org/10.4324/9781315795195>

Deng, M., Ma, J., Lv, X., & Ren, X. (2023). Academic performance and parenting styles differentially predict critical thinking skills and dispositions among primary students: Cross-sectional and cross-lagged evidence. *Thinking Skills and Creativity*, 50, Article 101384. <https://doi.org/10.1016/j.tsc.2023.101384>

Denton, M., Borrego, M., & Boklage, A. (2020). Community cultural wealth in science, technology, engineering, and mathematics education: A systematic review. *Journal of Engineering Education (Washington, D.C.)*, 109(3), 556–580. <https://doi.org/10.1002/jee.20322>

Deringer, S. A. (2017). Mindful Place-Based Education: Mapping the Literature. *The Journal of Experiential Education*, 40(4), 333–348. <https://doi.org/10.1177/1053825917716694>

Deshler, J. M., Miller, D., & Pascal, M. (2016). An Active Classroom: The Emerging Scholars Program at West Virginia University. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*, 26(9), 811–823. <https://doi.org/10.1080/10511970.2016.1191570>

Dick, D. M. (2017). Rethinking the Way We Do Research: The Benefits of Community-Engaged, Citizen Science Approaches and Nontraditional Collaborators. *Alcoholism, Clinical and Experimental Research*, 41(11), 1849–1856. <https://doi.org/10.1111/acer.13492>

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking Congruity Between Goals and Roles: A New Look at Why Women Opt Out of Science, Technology, Engineering, and Mathematics Careers. *Psychological Science*, 21(8), 1051–1057. <https://doi.org/10.1177/0956797610377342>

Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to stem careers: Evidence for a goal congruity perspective. *Journal of Personality*

and *Social Psychology*, 101(5), 902–918. <https://doi.org/10.1037/a0025199>

Diekman, A. B., & Steinberg, M. (2013). Navigating Social Roles in Pursuit of Important Goals: A Communal Goal Congruity Account of STEM Pursuits. *Social and Personality Psychology Compass*, 7(7), 487–501. <https://doi.org/10.1111/spc3.12042>

Diekman, A. B., Steinberg, M., Brown, E. R., Belanger, A. L., & Clark, E. K. (2017). A Goal Congruity Model of Role Entry, Engagement, and Exit: Understanding Communal Goal Processes in STEM Gender Gaps. *Personality and Social Psychology Review*, 21(2), 142–175. <https://doi.org/10.1177/1088868316642141>

Dika, S. L. (2012). Relations With Faculty as Social Capital for College Students: Evidence From Puerto Rico. *Journal of College Student Development*, 53(4), 596–610. <https://doi.org/10.1353/csd.2012.0051>

Dika, S. L., Pando, M. A., Tempest, B. Q., & Allen, M. E. (2018). Examining the Cultural Wealth of Underrepresented Minority Engineering Persisters. *Journal of Professional Issues in Engineering Education and Practice*, 144(2). [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000358](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000358)

Dotterer, A. M., McHale, S. M., & Crouter, A. C. (2009). The Development and Correlates of Academic Interests From Childhood Through Adolescence. *Journal of Educational Psychology*, 101(2), 509–519. <https://doi.org/10.1037/a0013987>

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education (Salem, Mass.)*, 103(3), 623–637. <https://doi.org/10.1002/sce.21499>

Dunbar-Wallis, A. K., Katcher, J., Moore, W., & Corwin, L. A. (2024). Bee The CURE: Increasing Student Science Self-Efficacy, Science Identity, and Predictors of Scientific Civic Engagement in a Community College CURE. *CBE Life Sciences Education*, 23(4), ar46. <https://doi.org/10.1187/cbe.24-01-0015>

Erkut, S., & Mokros, J. R. (1984). Professors as Models and Mentors for College Students. *American Educational Research Journal*, 21(2), 399–417. <https://doi.org/10.3102/00028312021002399>

Elbroch, M., Mwampamba, T. H., Santos, M. J., Zylberberg, M., Liebenberg, L., Minye, J., ... & Reddy, E. (2011). The value, limitations, and challenges of employing local experts in conservation research. *Conservation Biology*, 25(6), 1195–1202. <https://doi.org/10.1111/j.1523-1739.2011.01740.x>

Erikson, E. H. (1968). *Identity: Youth and crisis* (Vol. 68). Norton.

Espinosa, L. (2011). Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence. *Harvard Educational Review*, 81(2), 209–241. <https://doi.org/10.17763/haer.81.2.92315ww157656k3u>

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology*, 103(1), 206–222. <https://doi.org/10.1037/a0020743>

Faulstich Orellana, M. (2003) In other words: en otras palabras: learning from bilingual kids' translating/interpreting experiences. *Reading Research Quarterly*, 38(1), 12–34. <https://doi.org/10.1598/RRQ.38.1.2>

Ferraro, F., Etzion, D., & Gehman, J. (2015). Tackling Grand Challenges Pragmatically: Robust Action Revisited. *Organization Studies*, 36(3), 363–390. <https://doi.org/10.1177/0170840614563742>

Frederick, A., Monarrez, A., Morales, D. X., Daniels, H. A., Grineski, S. E., & Collins, T. W. (2023). “Your Family is Always With You”: Perceptions of Parental Relationships Among Hispanic/Latinx Young Adults Pursuing STEM Careers. *CBE Life Sciences Education*, 22(4), ar39. <https://doi.org/10.1187/cbe.22-06-0110>

Fuentes, M. V., Alvarado, A. R., Berdan, J., & DeAngelo, L. (2014). Mentorship Matters: Does Early Faculty Contact Lead to Quality Faculty Interaction? *Research in Higher Education*, 55(3), 288–307. <https://doi.org/10.1007/s11162-013-9307-6>

Fuesting, M. A., & Diekman, A. B. (2017). Not By Success Alone: Role Models Provide Pathways to Communal Opportunities in STEM. *Personality & Social Psychology Bulletin*, 43(2), 163–176. <https://doi.org/10.1177/0146167216678857>

Fullilove, R. E., & Treisman, P. U. (1990). Mathematics Achievement Among African American Undergraduates at the University of California, Berkeley: An Evaluation of the Mathematics Workshop Program. *The Journal of Negro Education*, 59(3), 463–478. <https://doi.org/10.2307/2295577>

Gallo, T., & Waitt, D. (2011). Creating a Successful Citizen Science Model to Detect and Report Invasive Species. *Bioscience*, 61(6), 459–465. <https://doi.org/10.1525/bio.2011.61.6.1>

Garcia, K. A. (2024). An examination of the “giving back” asset of first-generation Latinx premedical students in an emerging Hispanic-serving

institution. *Journal of Diversity in Higher Education*. <https://doi.org/10.1037/dhe0000607>

Garcia, N. M., & Bernal, D. D. (2021). Remembering and Revisiting Pedagogies of the Home. *American Educational Research Journal*, 58(3), 567–601. <https://doi.org/10.3102/0002831220954431>

Garibay, J. C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students?: STEM college students and social justice outcomes. *Journal of Research in Science Teaching*, 52(5), 610–632. <https://doi.org/10.1002/tea.21203>

Garibay, J. C. (2018). Beyond Traditional Measures of STEM Success: Long-Term Predictors of Social Agency and Conducting Research for Social Change. *Research in Higher Education*, 59(3), 349–381. <https://doi.org/10.1007/s11162-017-9470-2>

Garriott, P. O., Navarro, R. L., & Flores, L. Y. (2017). First-Generation College Students' Persistence Intentions in Engineering Majors. *Journal of Career Assessment*, 25(1), 93–106. <https://doi.org/10.1177/1069072716657533>

Garza, A. N., & Fullerton, A. S. (2018). Staying Close or Going Away: How Distance to College Impacts the Educational Attainment and Academic Performance of First-generation College Students. *Sociological Perspectives*, 61(1), 164–185. <https://doi.org/10.1177/0731121417711413>

Gatz, J. A., Kelly, A. M., & Bugallo, M. (2018). The Power of Peer Mentoring of Undergraduate Women in Engineering: Fostering Persistence through Academic and Social Integration. *Association for Engineering Education - Engineering Library Division Papers*.

Gee, J. P. (2000). Chapter 3 : Identity as an Analytic Lens for Research in Education. *Review of Research in Education*, 25(1), 99–125. <https://doi.org/10.3102/0091732X025001099>

George, R., & Kaplan, D. (1998). A structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88. *Science Education*, 82(1), 93–109.

Gladstone, J. R., Tallberg, M., Jaxon, J., & Cimpian, A. (2024). What makes a role model motivating for young girls? The effects of the role model's growth versus fixed mindsets about ability and interest. *Journal of Experimental Child Psychology*, 238, Article 105775. <https://doi.org/10.1016/j.jecp.2023.105775>

Gladstone, J. R., & Cimpian, A. (2021). Which role models are effective for which students? A systematic review and four recommendations for

maximizing the effectiveness of role models in STEM. *International Journal of STEM Education*, 8(1), Article 59. <https://doi.org/10.1186/s40594-021-00315-x>

Gibbs Jr, K. D., & Griffin, K. A. (2017). What do I want to be with my PhD? The roles of personal values and structural dynamics in shaping the career interests of recent biomedical science PhD graduates. *CBE—Life Sciences Education*, 12(4), 711–723. <https://doi.org/10.1187/cbe.13-02-0021>

Gruenewald, D. A. (2003). Foundations of Place: A Multidisciplinary Framework for Place-Conscious Education. *American Educational Research Journal*, 40(3), 619–654. <https://doi.org/10.3102/00028312040003619>

Guessous, L., Moore, K., Walters, J., Roth, B. J., DeVreugd, L., & Reger, J. (2015). Developing an Effective Mentoring Program for Early-career STEM Faculty: Lessons Learned from the First Three Years of an ADVANCE PAID Program. *Association for Engineering Education - Engineering Library Division Papers*, 26.490.1. <https://doi.org/10.18260/p.23829>

Guiffrida, D. A., Kiyama, J. M., Waterman, S. J., & Museus, S. D. (2012). Moving from Cultures of Individualism to Cultures of Collectivism in Support of Students of Color. In *Creating Campus Cultures* (1st ed., pp. 68–87). Routledge. <https://doi.org/10.4324/9780203832417-4>

Guillory, J. P. (2008). *Diverse pathways of “giving back” to tribal community: Perceptions of Native American college graduates*. ProQuest Dissertations & Theses.

Guillory, R. M., & Wolverton, M. (2008). It’s About Family: Native American Student Persistence in Higher Education. *The Journal of Higher Education (Columbus)*, 79(1), 58–87. <https://doi.org/10.1353/jhe.2008.0001>

Habig, B., & Gupta, P. (2021). Authentic STEM research, practices of science, and interest development in an informal science education program. *International Journal of STEM Education*, 8(1), Article 57. <https://doi.org/10.1186/s40594-021-00314-y>

Habig, B., Gupta, P., & Adams, J. D. (2021). Disrupting deficit narratives in informal science education: applying community cultural wealth theory to youth learning and engagement. *Cultural Studies of Science Education*, 16(2), 509–548. <https://doi.org/10.1007/s11422-020-10014-8>

Haney, J. J., Lumpe, A. T., Czerniak, C. M., & Egan, V. (2002). From Beliefs to Actions: The Beliefs and Actions of Teachers Implementing Change. *Journal of Science Teacher Education*, 13(3), 171–187. <https://doi.org/10.1023/A:1016565016116>

Härkönen, U. (2001). *The Bronfenbrenner ecological systems theory of human development*.

Hart, M. (2014). Internships as invisible labor. *Emp. Rts. & Emp. Pol'y J.*, 18, 141.

Haworth, C. M. A., Dale, P., & Plomin, R. (2008). A Twin Study into the Genetic and Environmental Influences on Academic Performance in Science in nine-year-old Boys and Girls. *International Journal of Science Education*, 30(8), 1003–1025. <https://doi.org/10.1080/09500690701324190>

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, 47(8), 978–1003. <https://doi.org/10.1002/tea.20363>

Henderson, H. L., Bloodhart, B., Adams, A. S., Barnes, R. T., Burt, M., Clinton, S., Godfrey, E., Pollack, I., Fischer, E. V., & Hernandez, P. R. (2022). Seeking congruity for communal and agentic goals: A longitudinal examination of U.S. college women's persistence in STEM. *Social Psychology of Education: An International Journal*, 25(2-3), 649–674. <https://doi.org/10.1007/s11218-021-09679-y>

Herrera, F., & Kovats Sánchez, G. (2022). Curando La Comunidad [Healing the Community]: Community-Centered STEM Identity. *Journal of Hispanic Higher Education*, 21(2), 135–150. <https://doi.org/10.1177/15381927211069543>

Heyman, J. B. (2016). *Pathways into STEM among low-income, urban immigrant emergent bilingual/multilingual young adults: Opportunity, access, and persistence*. ProQuest Dissertations & Theses.

Hofstede, G., & Rowley, C. (2002). [Rev. of *Culture's consequences: comparing values, behaviors, institutions and organizations across nations*]. *Asia Pacific Business Review*, 9(1), 115–116.

Hoh, Y. K. (2009). Using Biographies of Outstanding Women in Bioengineering to Dispel Biology Teachers' Misperceptions of Engineers. *The American Biology Teacher*, 71(8), 458–463. <https://doi.org/10.2307/20565358>

Howard, M., Alexiades, A., Schuster, C., & Raya, R. (2024). Indigenous Student Perceptions on Cultural Relevance, Career Development, and Relationships in a Culturally Relevant Undergraduate STEM Program. *International Journal of Science and Mathematics Education*, 22(1), 1–23. <https://doi.org/10.1007/s10763-023-10360-3>

Hsu, E., Murphy, T. J., & Treisman, P. U. (2008). Supporting high minority

achievement in introductory collegiate mathematics courses: What We Have Learned from 30 Years of The Emerging Scholars Program. *Making the connection: Research and practice in undergraduate mathematics education*, 205-220. <https://doi.org/10.5948/UPO9780883859759.017>

Hughes, G. (2001). Exploring the Availability of Student Scientist Identities within Curriculum Discourse: An anti-essentialist approach to gender-inclusive science. *Gender and Education*, 13(3), 275–290. <https://doi.org/10.1080/09540250120063562>

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research*, 2010(148), 5–15. <https://doi.org/10.1002/ir.357>

Isenegger, K., George, K. L., Bruno, P., & Lewis, C. M. (2023). Goal-Congruity Theory Predicts Students' Sense of Belonging in Computing Across Racial/Ethnic Groups. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1*, 1069–1075. <https://doi.org/10.1145/3545945.3569834>

Ives, J., Falk, J., & Drayton, B. (2024). Broadening participation in STEM through equity-minded high-impact practices: a multimodal systematic review. *Higher Education*, 88(3), 1183–1203. <https://doi.org/10.1007/s10734-023-01165-y>

Jamieson, A. C., Jamieson, L. H., & Johnson, A. C. (2012). Application of non-programming focused treisman-style workshops in introductory computer science. *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education*, 271–276. <https://doi.org/10.1145/2157136.2157219>

Jaumot-Pascual, N., DeerInWater, K., Ong, M., & Silva, C. B. (2023). “I can do data for my people”: experiences of giving back for Native undergraduates in computing. *Cultural Studies of Science Education*, 18(3), 879–909. <https://doi.org/10.1007/s11422-023-10172-5>

Jaumot-Pascual, N., Ong, M., & Silva, C. B. (2023). The role of giving back in the persistence of women of color graduate students in engineering and computer science. *Journal of Women and Minorities in Science and Engineering*, 29(6), 81–110. <https://doi.org/10.1615/JWomenMinorScienEng.2022037320>

Jensen, A. R. (1967). How much can we boost IQ and scholastic achievement?.

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist

examination of the journeys of three women of color in science. *Journal of Research in Science Teaching*, 48(4), 339–366. <https://doi.org/10.1002/tea.20411>

Johnson, A., & Elliott, S. (2020). Culturally Relevant Pedagogy: A Model To Guide Cultural Transformation in STEM Departments. *Journal of Microbiology & Biology Education*, 21(1). <https://doi.org/10.1128/jmbe.v21i1.2097>

Johnson, W. B., & Griffin, K. A. (2025). *On Being a Mentor: A Guide for Higher Education Faculty* (3rd ed., Vol. 1). Routledge. <https://doi.org/10.4324/9781003195825>

Jones, J. C., & Washko, S. (2022). More than fun in the sun: The pedagogy of field trips improves student learning in higher education. *Journal of Geoscience Education*, 70(3), 292–305. <https://doi.org/10.1080/10899995.2021.1984176>

Jones, S. R. (2009). Constructing Identities at the Intersections: An Autoethnographic Exploration of Multiple Dimensions of Identity. *Journal of College Student Development*, 50(3), 287–304. <https://doi.org/10.1353/csd.0.0070>

Jones, S. R., & McEwen, M. K. (2000). A Conceptual Model of Multiple Dimensions of Identity. *Journal of College Student Development*, 41(4), 405.

Joshi, M. P., Benson-Greenwald, T. M., & Diekman, A. B. (2022). Unpacking Motivational Culture: Diverging Emphasis on Communitality and Agency Across STEM Domains. *Motivation Science*, 8(4), 316–329. <https://doi.org/10.1037/mot0000276>

Jungert, T., Levine, S., & Koestner, R. (2020). Examining how parent and teacher enthusiasm influences motivation and achievement in STEM. *The Journal of Educational Research (Washington, D.C.)*, 113(4), 275–282. <https://doi.org/10.1080/00220671.2020.1806015>

Kanagala, V., Rendón, L., & Nora, A. (2016). A framework for understanding Latino/a cultural wealth. *Diversity & Democracy*, 19(1), 18–19.

Katzer, A. M., Boydston, E. E., Akresh, M. E., Briggs, J. S., Cooper, K., Barve, V., Lee, L., & Morelli, T. L. (2025). Biodiversity on public lands: How community science can help. *Conservation Science and Practice*, 7(5). <https://doi.org/10.1111/csp2.70016>

Kennedy, M., Daugherty, R., Garibay, C., Sanford, C., Koerner, J., Lewin, J., & Braun, R. (2016). Science Club: Bridging In-School and Out-of-School STEM Learning Through a Collaborative, Community-Based After-School Program. *Connected Science Learning*, 1(1). <https://doi.org/10.1080/247>

58779.2016.12420447

Kermish-Allen, R., Peterman, K., & Bevc, C. (2019). The utility of citizen science projects in K-5 schools: measures of community engagement and student impacts. *Cultural Studies of Science Education*, 14(3), 627–641. <https://doi.org/10.1007/s11422-017-9830-4>

Kilgo, C. A., Sheets, J. K. E., & Pascarella, E. T. (2015). The link between high-impact practices and student learning: Some longitudinal evidence. *Higher Education*, 69(4), 509–525. <https://doi.org/10.1007/s10734-014-9788-z>

Kimmerer, R. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants* (1st ed.). Milkweed Editions.

Kimmerer, R. W. (2024). *The serviceberry: Abundance and reciprocity in the natural world*. New York, NY: Scribner.

Kong, X., Dabney, K. P., & Tai, R. H. (2014). The Association Between Science Summer Camps and Career Interest in Science and Engineering. *International Journal of Science Education. Part B. Communication and Public Engagement*, 4(1), 54–65. <https://doi.org/10.1080/21548455.2012.760856>

Kristof-Brown, A. L. Zimmerman, & RD, Johnson, EC (2005). Consequences of individuals' fit at work: A meta-analysis of person-job, person-organization, person-group, and person-supervisor fit. *Personnel Psychology*, 58(2), 281–342. <https://doi.org/10.1111/j.1744-6570.2005.00672.x>

Kroger, J. (2006). Identity development during adolescence. *Blackwell handbook of adolescence*, 205–226.

Krogh, L. B., & Andersen, H. M. (2013). “Actually, I may be clever enough to do it’ : using identity as a lens to investigate students” trajectories towards science and university. *Research in Science Education (Australasian Science Education Research Association)*, 43(2), 711–731. <https://doi.org/10.1007/s11165-012-9285-2>

Kuh, G. D. (2008). High-Impact educational practices. *Peer Review*, 10(4), 30. https://link.gale.com/apps/doc/A203770127/AONE?u=nysl_oweb&sid=googleScholar&xid=b63c5a22

Lakin, J., Marghitu, D., Davis, V., & Davis, E. (2021). Introducing Engineering as an Altruistic STEM Career. *The Science Teacher (National Science Teachers Association)*, 88(4), 29–35. <https://doi.org/10.1080/00368555.2021.12293596>

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Lavie Alon, N., & Tal, T. (2015). Student self-reported learning outcomes of field trips: The pedagogical impact. *International Journal of Science Education*, 37(8), 1279–1298. <https://doi.org/10.1080/09500693.2015.1034797>

Lawrence-Lightfoot, S. (1978). *Worlds apart: Relationships between families and schools*. Basic Books.

Leeper, C. (2015). Do I belong?: Gender, peer groups, and STEM achievement. *International Journal of Gender, Science and Technology*, 7(2), 166–179.

Lehmeidi Dong, M., Feng, Z., McLamb, F., Griffin, L., Vazquez, A., Hirata, K. K., Bozinovic, L., Vasquez, M. F., Bozinovic, G., & Dewsbury, B. M. (2023). Life Science Research Immersion Program Improves STEM-Specific Skills and Science Attitudes among Precollege Students. *Journal of Microbiology & Biology Education*, 24(1). <https://doi.org/10.1128/jmbe.00078-22>

Lewis, O. (1969). Review of C. Valentine's, *Culture and poverty: A critique and counter proposals*. *Current Anthropology*, 10, 189–192.

Litchfield, K., & Javernick-Will, A. (2015). “I Am an Engineer AND”: A Mixed Methods Study of Socially Engaged Engineers. *Journal of Engineering Education (Washington, D.C.)*, 104(4), 393–416. <https://doi.org/10.1002/jee.20102>

López, E. J., Basile, V., Landa-Posas, M., Ortega, K., & Ramirez, A. (2019). Latinx Students' Sense of Familismo in Undergraduate Science and Engineering. *Review of Higher Education*, 43(1), 85–111. <https://doi.org/10.1353/rhe.2019.0091>

Luedke, C. L. (2017). Person First, Student Second: Staff and Administrators of Color Supporting Students of Color Authentically in Higher Education. *Journal of College Student Development*, 58(1), 37–52. <https://doi.org/10.1353/csd.2017.0002>

Madsen, S. E., Abouras, R., Alleman, N. F., Ham, P. L., & Wilby, T. (2023). “Success Is Not Measured Through Wealth”: Expanding Visions of Success for Low-Income STEM Students. *Journal of College Student Retention: Research, Theory & Practice*, 0(0). <https://doi.org/10.1177/15210251231213044>

Mak, A. S., & Chan, H. (1995). Chinese family values in Australia. *Families and cultural diversity in Australia*, 70–95.

Malott, K. M. (2010). Being Mexican: Strengths and Challenges of Mexican-Origin Adolescents. *Journal of School Counseling*, 8(12).

Marín, G., & Marín, B. V. (1991). *Research with Hispanic populations* (1st ed., Vol. 23, pp. ix–ix). Sage Publications. <https://doi.org/10.1177/15210251231213044>

org/10.4135/9781412985734

Markus, H., & Nurius, P. (1986). Possible Selves. *The American Psychologist*, 41(9), 954–969. <https://doi.org/10.1037/0003-066X.41.9.954>

Martinez, M. A. (2013). (Re)considering the Role “Familismo” Plays in Latina/o High School Students’ College Choices. *The High School Journal*, 97(1), 21–40. <https://doi.org/10.1353/hsj.2013.0019>

Marx, D. M., & Ko, S. J. (2012). Superstars “like” me: The effect of role model similarity on performance under threat. *European Journal of Social Psychology*, 42(7), 807–812. <https://doi.org/10.1002/ejsp.1907>

Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing Whether She Belongs: Stereotypes Undermine Girls’ Interest and Sense of Belonging in Computer Science. *Journal of Educational Psychology*, 108(3), 424–437. <https://doi.org/10.1037/edu0000061>

McAlpine, L., Amundsen, C., & Turner, G. (2014). Identity-trajectory: Reframing early career academic experience. *British Educational Research Journal*, 40(6), 952–969. <https://doi.org/10.1002/berj.3123>

McClellan, G. S., Tippeconnic Fox, M. J., & Lowe, S. C. (2005). Where we have been: A history of Native American higher education. *New Directions for Student Services*, 2005(109). <https://doi.org/10.1002/ss.149>

McComas, W. F. (2002). The Principal Elements of the Nature of Science: Dispelling the Myths. In *The Nature of Science in Science Education* (pp. 53–70). Springer Netherlands. https://doi.org/10.1007/0-306-47215-5_3

McCoy, D. L., Winkle-Wagner, R., & Luedke, C. L. (2015). Colorblind mentoring? Exploring white faculty mentoring of students of color. *Journal of Diversity in Higher Education*, 8(4), 225–242. <https://doi.org/10.1037/a0038676>

McGee, E. O. (2016). Devalued Black and Latino Racial Identities: A by-product of STEM college culture? *American Educational Research Journal*, 53(6), 1626–1662. <https://doi.org/10.3102/0002831216676572>

McGee, E., & Bentley, L. (2017). The equity ethic: Black and latinx college students reengineering their STEM careers toward justice. *American Journal of Education*, 124(1), 1–36. <https://doi.org/10.1086/693954>

McGee, E. O., & Martin, D. B. (2011). “You would not believe what I have to go through to prove my intellectual value!” Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal*, 48(6), 1347–1389. <https://doi.org/10.3102/0002831211423972>

McGee, E. O., & Pearman, F. A. (2014). Risk and protective factors in mathematically talented Black male students: Snapshots from kindergarten through eighth grade. *Urban Education*, 49(4), 363–393. <https://doi.org/10.1177/0042085914525791>

McKnight, M. R. (2016). *STEM-themed schools: A case study of its effect on student educational pathways*. ProQuest Dissertations & Theses.

Metzger, K. J., Dingel, M., & Brown, E. (2023). “No matter what your story is, there is a place for you in science”: Students’ Ability to Relate to Scientists Positively Shifts after Scientist Spotlight Assignments, Especially for First-Generation Students and Women. *CBE—Life Sciences Education*, 22(1), ar12. <https://doi.org/10.1187/cbe.22-06-0103>

Miller, D., Deshler, J., McEldowney, T., Stewart, J., Fuller, E., Pascal, M., & Michaluk, L. (2021). Supporting Student Success and Persistence in STEM With Active Learning Approaches in Emerging Scholars Classrooms. *Frontiers in Education*, 6. <https://doi.org/10.3389/educ.2021.667918>

Milner-Bolotin, M., & Marotto, C. C. F. (2018). Parental engagement in children’s STEM education. Part I: Meta-analysis of the literature. *LUMAT*, 6(1), 41. <https://doi.org/10.31129/LUMAT.6.1.292>

Mobley, C., & Brawner, C. E. (2019). “Life prepared me well for succeeding”: The Enactment of Community Cultural Wealth, Experiential Capital, and Transfer Student Capital by First-Generation Engineering Transfer Students. *Community College Journal of Research and Practice*, 43(5), 353–369. <https://doi.org/10.1080/10668926.2018.1484823>

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice*, 31(2), 132–141. <https://doi.org/10.1080/00405849209543534>

Mondisa, J. L. (2020). The role of social capital in African American STEM mentoring relationships. *Journal of Women and Minorities in Science and Engineering*, 26(2), 125–153. <https://doi.org/10.1615/JWomenMinorScienEng.2020022267>

Montoya, A., Master, A., & Cheryan, S. (2020). Increasing interest in computer science through group work: A goal congruity approach.

Moore, J. L., Madison-Colmore, O., & Smith, D. M. (2003). The Prove-Them-Wrong Syndrome: Voices from Unheard African-American Males in Engineering Disciplines. *The Journal of Men’s Studies*, 12(1), 61–73. <https://doi.org/10.3149/jms.1201.61>

Moriarty, M., Howe, S., & Elena Rose Yasinski. (2013). Job Shadowing: Improving Interest and Persistence for Women in Engineering. *Association for Engineering Education - Engineering Library Division Papers*, 23.836.1.

Morgenroth, T., Ryan, M. K., & Peters, K. (2015). The Motivational Theory of Role Modeling: How Role Models Influence Role Aspirants' Goals. *Review of General Psychology*, 19(4), 465–483. <https://doi.org/10.1037/gpr0000059>

Murphy, K. M., Kelp, N. C., & Dewsbury, B. M. (2023). Undergraduate STEM Students' Science Communication Skills, Science Identity, and Science Self-Efficacy Influence Their Motivations and Behaviors in STEM Community Engagement. *Journal of Microbiology & Biology Education*, 24(1). <https://doi.org/10.1128/jmbe.00182-22>

Mwangi, C. A. G., Johnson, J. M., & Brown, V. K. M. (2021). Family and community engagement among college students in science, technology, engineering, and mathematics. *Journal of Women and Minorities in Science and Engineering*, 27(4), 35–57. <https://doi.org/10.1615/JWomenMinorScienEng.2021032901>

Nalipay, M.J.N., Huang, B., Jong, M.S.Y. *et al.* Promoting STEM learning perseverance through recognizing communal goals: understanding the impact of empathy and citizenship. *International Journal of STEM Education* 11, 17 (2024). <https://doi.org/10.1186/s40594-024-00471-w>

National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. The National Academies Press. <https://doi.org/10.17226/11463>

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: National Academies Press. <https://doi.org/10.17226/18290>

Nicholls, G. M., Wolfe, H., Besterfield-Sacre, M., Shuman, L. J., & Larпкиattaworn, S. (2007). A Method for Identifying Variables for Predicting STEM Enrollment. *Journal of Engineering Education (Washington, D.C.)*, 96(1), 33–44. <https://doi.org/10.1002/j.2168-9830.2007.tb00913.x>

O'Neill, T., Finau-Faumuina, B. M., & Ford, T. U. L. (2023). Toward decolonizing STEM : Centering place and sense of place for community-based problem-solving. *Journal of Research in Science Teaching*, 60(8), 1755–1785. <https://doi.org/10.1002/tea.21858>

Pace, B. (Ed.). (2007). *Renaissance of sickle cell disease research in the Genome Era*. World Scientific.

Pacheco, M., & Chávez-Moreno, L. (2021). Bilingual education for self-determination: Re-centering Chicana/o/x and Latina/o/x student voices. *Bilingual Research Journal*, 44(4), 522–538. <https://doi.org/10.1080/15235882.2022.2052203>

Page-Reeves, J., Cortez, G. L., Ortiz, Y., Moffett, M., Deerinwater, K., & Medin, D. (2019). Situating giving back for Native Americans pursuing careers in STEM: “You don’t just take, you give something back”. *Intersections: Critical Issues in Education*, 3(1), 4. <https://digitalrepository.unm.edu/intersections/vol3/iss1/4>

Parsons, E. C. (1997). Black high school females’ images of the scientist: Expression of culture. *Journal of Research in Science Teaching*, 34(7), 745–768.

Patiniotis, J., & Holdsworth, C. (2005). “Seize That Chance!” Leaving Home and Transitions to Higher Education. *Journal of Youth Studies*, 8(1), 81–95. <https://doi.org/10.1080/13676260500063710>

Pattison, S., Ramos Montañez, S., & Svarovsky, G. (2022). Family values, parent roles, and life challenges: Parent reflections on the factors shaping long-term interest development for young children and their families participating in an early childhood engineering program. *Science Education*, 106(6), 1568–1604. <https://doi.org/10.1002/scs.21763>

Pawley, A. L. (2019). Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education. *Journal of Engineering Education (Washington, D.C.)*, 108(1), 13–31. <https://doi.org/10.1002/jee.20247>

Pendakur, S. L., Quaye, S. J., & Harper, S. R. (2019). The heart of our work: Equitable engagement for students in US higher education. In *Student engagement in higher education* (pp. 1-16). Routledge.

Peralta, C., Caspary, M., & Boothe, D. (2013). Success factors impacting Latina/o persistence in higher education leading to STEM opportunities. *Cultural Studies of Science Education*, 8(4), 905–918. <https://doi.org/10.1007/s11422-013-9520-9>

Pérez II, D. (2017). In Pursuit of Success: Latino Male College Students Exercising Academic Determination and Community Cultural Wealth. *Journal of College Student Development*, 58(2), 123–140. <https://doi.org/10.1353/csd.2017.0011>

Pérez, D., Zamora, B. T., & Pontious, M. W. (2018). Capitalizing on Interpersonal Thriving: Exploring the Community Cultural Wealth in Latino Undergraduate Men’s Peer Networks. *Journal of the First-Year Experience &*

Students in Transition, 30(1), 11–31.

Peters, A. W., Tisdale, V. A., & Swinton, D. J. (2019). High-impact educational practices that promote student achievement in STEM. In *Broadening participation in STEM: Effective methods, practices, and programs* (pp. 183–196). Emerald Publishing Limited. <https://doi.org/10.1108/S1479-364420190000022008>

Pocock, M. J. O., Adriaens, T., Bertolino, S., Eschen, R., Essl, F., Hulme, P. E., Jeschke, J. M., Roy, H. E., Teixeira, H., & de Groot, M. (2024). Citizen science is a vital partnership for invasive alien species management and research. *iScience*, 27(1), Article 108623. <https://doi.org/10.1016/j.isci.2023.108623>

Powers, T. (2018). *Giving Back as a Retention Influence of Urban American Indian and Alaska Native Women Community College Students*. ProQuest Dissertations & Theses.

Prasad, A., Lal, P., Wolde, B., Smith, M., Zhu, M., Samanthula, B. K., & Panorkou, N. (2022). Exploring the human-nature connection and the perceived risk of nature in children. *Applied Environmental Education and Communication*, 21(1), 87–101. <https://doi.org/10.1080/1533015X.2021.1991508>

Purdy, E. (2021). Changing Demographics in higher education. *EBSCO Information Services, Inc.* | www.ebsco.com.

Reyna, M. S. (2022). *Design Justice in Community-Oriented Engineering Pedagogy and Practice*. DigitalCommons@CalPoly.

Rendón, L., Nora, A., Bledsoe, R., & Kanagala, V. (2020). Científicos Latinxs. *High-Achieving Latino Students: Successful Pathways Toward College and Beyond; Information Age Publishing: Charlotte, NC, USA*, 159–178.

Revelo Alonso, R. A. (2015). *Engineering familia: The role of a professional organization in the development of engineering identities of Latina/o undergraduates*. ProQuest Dissertations & Theses.

Revelo, R. A., & Baber, L. D. (2018). Engineering Resistors: Engineering Latina/o Students and Emerging Resistant Capital. *Journal of Hispanic Higher Education*, 17(3), 249–269. <https://doi.org/10.1177/1538192717719132>

Reyes, N. A. S., Lopez, J. D., Lowe, S. C., Shotton, H. J., Youngbull, N. R., & Waterman, S. J. (2024). Ripples on the Water: Understanding Giving Back among Native College Students. In *Developments Beyond the Asterisk* (1st ed., pp. 104–118). Routledge. <https://doi.org/10.4324/9781032626277-9>

Riesch, H., & Potter, C. (2014). Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions. *Public Understanding*

of Science, 23(1), 107–120. <https://doi.org/10.1177/0963662513497324>

Rincón, B., Fernández, É., & Hinojosa, J. K. (2020). “I wanted to follow in her footsteps”: Activating, Nurturing, and Extending Community Cultural Wealth for Students of Color Entering STEM Pathways. *Teachers College Record* (1970), 122(9), 1–36. <https://doi.org/10.1177/016146812012200903>

Rincón, B. E., & Rodriguez, S. (2021). Latinx Students Charting Their Own STEM Pathways: How Community Cultural Wealth Informs Their STEM Identities. *Journal of Hispanic Higher Education*, 20(2), 149–163. <https://doi.org/10.1177/1538192720968276>

Ritter, P. L., & Mont-Reynaud, R. (1993). Minority Parents and Their Youth: Concern, Encouragement, and Support. *Families and schools in a pluralistic society*, 107.

Robinson, T., & Ward, J. V. (1991). “A Belief in Self Far Greater Than Anyone’s Disbelief”: Cultivating Resistance Among African American Female Adolescents. *Women & Therapy*, 11(3–4), 87–103. https://doi.org/10.1300/J015V11N03_06

Rögele, A., Scheiter, K., & Randler, C. (2022). Can involvement induced by guidance foster scientific reasoning and knowledge of participants of a citizen science project? *International Journal of Science Education. Part B. Communication and Public Engagement*, 12(2), 94–110. <https://doi.org/10.1080/21548455.2022.2043567>

Rogers, K. R., Maxwell, D., & Robinson, S. R. (2018). Influences of Academic Success among Low-Income Minority Students: A Qualitative Interpretive Meta-synthesis of Student, Educator, and Parent Experiences. *School Social Work Journal*, 43(1), 38–59.

Roth, W. M., & Tobin, K. (2007). *Science, learning, identity: Sociocultural and cultural-historical perspectives* (Vol. 7). Brill.

Royse, E. A., Sutton, E., Peffer, M. E., & Holt, E. A. (2020). The Anatomy of Persistence: Remediation and Science Identity Perceptions in Undergraduate Anatomy and Physiology. *International Journal of Higher Education*, 9(5), 283–299. <https://doi.org/10.5430/ijhe.v9n5p283>

Rubba, P. A., Homer, J. K., & Smith, J. M. (1981). A study of two misconceptions about the nature of science among junior high school students. *School Science and Mathematics*, 81(3), 221–226. <https://doi.org/10.1111/j.1949-8594.1981.tb17140.x>

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African

American students at a predominantly white institution. *Journal of Research in Science Teaching*, 42(6), 691–715. <https://doi.org/10.1002/tea.20068>

Saavedra, J. A., Ruiz, L., & Alcalá, L. (2022). Critical Service-Learning Supports Social Justice and Civic Engagement Orientations in College Students. *Michigan Journal of Community Service Learning*, 28(1), 1. <https://doi.org/10.3998/mjcs1.292>

Salazar, C., Park, J. J., & Parikh, R. M. (2020). STEM student-faculty relationships: The influence of race and gender on access to career-related opportunities. *Journal of Women and Minorities in Science and Engineering*, 26(5), 413–446. <https://doi.org/10.1615/JWomenMinorScienEng.2020031959>

Salis Reyes, N. A. (2019). “What am I doing to be a good ancestor?”: An Indigenized phenomenology of giving back among Native college graduates. *American Educational Research Journal*, 56(3), 603–637. <https://doi.org/10.3102/0002831218807180>

Salomone, M., & Kling, T. (2017). Required peer-cooperative learning improves retention of STEM majors. *International Journal of STEM Education*, 4(1), 19. <https://doi.org/10.1186/s40594-017-0082-3>

Salvatierra, L., & Cabello, V. (2022). Starting at Home: What Does the Literature Indicate about Parental Involvement in Early Childhood STEM Education? *Education Sciences*, 12(3), 218. <https://doi.org/10.3390/educsci12030218>

Samuelson, C. C., & Litzler, E. (2016). Community Cultural Wealth: An Assets-Based Approach to Persistence of Engineering Students of Color. *Journal of Engineering Education*, 105(1), 93–117. <https://doi.org/10.1002/jee.20110>

Sausner, E. B., Wentzel, C., & Pitarresi, J. (2024). “I know what I need to learn”: The intersection of aspirational and navigational capitals for marginalized-identity STEM students. *Journal of Engineering Education*, 113(2), 488–508. <https://doi.org/10.1002/jee.20595>

Schmidt, J. A., Smith, P. E., Vogt, K. E., & Schmidt, L. C. (2003). Innovative educational opportunities for women in stem: Research Internships in Science and Engineering (RISE). 33rd Annual Frontiers in Education, 2003. *FIE 2003*, 2, F1D-18. <https://doi.org/10.1109/FIE.2003.1264676>

Schreiner, C., & Sjøberg, S. (2007). Science education and youth’s identity construction-two incompatible projects?. In *The re-emergence of values in science education* (pp. 231–247). Brill.

Seifan, M., Lal, N., & Berenjian, A. (2022). Effect of undergraduate research on students' learning and engagement. *International Journal of Mechanical Engineering Education*, 50(2), 326–348. <https://doi.org/10.1177/0306419021988962>

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving* (Vol. 34). Westview Press, Boulder, CO.

Sfard, A. (1998). On Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher*, 27(2), 4–13. <https://doi.org/10.2307/1176193>

Shahali, E. H., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2017). STEM Learning through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(5), 1189. <https://doi.org/10.12973/eurasia.2017.00667a>

Shelton, L. (2018). *The Bronfenbrenner Primer: A Guide to Develcology* (1st ed., Vol. 1). Routledge. <https://doi.org/10.4324/9781315136066>

Shelton, L. J., & Thompson, C. J. (2023). Exploring an Asset-Based Approach to Aspirational Capital Among Undocumented Latinx College Students. *Journal of College Student Development*, 64(1), 48–63. <https://doi.org/10.1353/csd.2023.0001>

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, 24(9), 467–471. <https://doi.org/10.1016/j.tree.2009.03.017>

Simunovic, M., & Babarovic, T. (2020). The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research. *Social Psychology of Education*, 23(3), 701–719. <https://doi.org/10.1007/s11218-020-09555-1>

Smith, H., Allf, B., Larson, L., Futch, S., Lundgren, L., Pacifici, L., & Cooper, C. (2021). Leveraging Citizen Science in a College Classroom to Build Interest and Efficacy for Science and the Environment. *Citizen Science : Theory and Practice*, 6(1), 29. <https://doi.org/10.5334/cstp.434>

Smith, J. L., Cech, E., Metz, A., Huntoon, M., & Moyer, C. (2014). Giving Back or Giving Up: Native American Student Experiences in Science and Engineering. *Cultural Diversity & Ethnic Minority Psychology*, 20(3), 413–429. <https://doi.org/10.1037/a0036945>

Solorzano, D. (1992). Chicano mobility aspirations: A theoretical and empirical note. *Latino Studies Journal*, 3(1), 48–66.

Solorzano, D. G. (1997). Images and Words that Wound: Critical Race Theory, Racial Stereotyping, and Teacher Education. *Teacher Education Quarterly*, 24(3), 5–19.

Sowells, E., Waller, L., Ofori-Boadu, A., & Bullock, G. (2016). Using technology summer camp to stimulate the interest of female high school students in technology careers. *2016 Portland International Conference on Management of Engineering and Technology (PICMET)*, 1688–1696. <https://doi.org/10.1109/PICMET.2016.7806601>

Stanton-Salazar, R. D., & Spina, S. U. (2000). The Network Orientations of Highly Resilient Urban Minority Youth: A Network-Analytic Account of Minority Socialization and Its Educational Implications. *The Urban Review*, 32(3), 227–261. <https://doi.org/10.1023/A:1005122211864>

Starr, C. R., Tulagan, N., & Simpkins, S. D. (2022). Black and Latinx Adolescents' STEM Motivational Beliefs: a Systematic Review of the Literature on Parent STEM Support. *Educational Psychology Review*, 34(4), 1877–1917. <https://doi.org/10.1007/s10648-022-09700-6>

Steffen, H. (2010). Student internships and the privilege to work. *Cultural Logic: A Journal of Marxist Theory & Practice*, 17.

Steinberg, M., & Diekman, A. B. (2017). Elevating Positivity toward STEM Pathways through Communal Experience: The Key Role of Beliefs that STEM Affords Other-Oriented Goals. *Analyses of Social Issues and Public Policy*, 17(1), 235–261. <https://doi.org/10.1111/asap.12135>

Stets, J. E., & Burke, P. J. (2000). Identity Theory and Social Identity Theory. *Social Psychology Quarterly*, 63(3), 224–237. <https://doi.org/10.2307/2695870>

Strayhorn, T. L. (2010). The Role of Schools, Families, and Psychological Variables on Math Achievement of Black High School Students. *The High School Journal*, 93(4), 177–194. <https://doi.org/10.1353/hsj.2010.0003>

Suárez-Orozco, M., & Suárez-Orozco, C. (2000). Some conceptual considerations in the interdisciplinary study of immigrant children. *Immigrant voices: In search of educational equity*, 17–36.

Sullivan, B. L., Aycrigg, J. L., Barry, J. H., Bonney, R. E., Bruns, N., Cooper, C. B., Damoulas, T., Dhondt, A. A., Dietterich, T., Farnsworth, A., Fink, D., Fitzpatrick, J. W., Fredericks, T., Gerbracht, J., Gomes, C., Hochachka, W. M., Iliff, M. J., Lagoze, C., La Sorte, F. A., ... Kelling, S. (2014). The eBird enterprise: An integrated approach to development and application of citizen science. *Biological Conservation*, 169, 31–40. <https://doi.org/10.1016/j.biocn.2014.05.011>

biocon.2013.11.003

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, 50(10), 1143–1179. <https://doi.org/10.1002/tea.21123>

Taylor, W. P. (1936). What is Ecology and What Good is It? *Ecology*, 17(3), 333–346. <https://doi.org/10.2307/1931838>

Teron, L. (2022). Deconstructing inequality: Cumulative impacts, environmental justice, and interstate redevelopment. *Rich. Pub. Int. L. Rev.*, 25, 127.

Tey, T. C. Y., Moses, P., & Cheah, P. K. (2020). Teacher, parental and friend influences on STEM interest and career choice intention. *Issues in Educational Research*, 30(4), 1558–1575.

Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2015). The Role of Altruistic Values in Motivating Underrepresented Minority Students for Biomedicine. *Bioscience*, 65(2), 183–188. <https://doi.org/10.1093/biosci/biu199>

Tibbetts, Y., Harackiewicz, J. M., Priniski, S. J., & Canning, E. A. (2016). Broadening participation in the life sciences with social-psychological interventions. *CBE—Life Sciences Education*, 15(3), es4. <https://doi.org/10.1187/cbe.16-01-0001>

Tolbert, D. A. (2016). *Living, Learning, and Leveraging: An Investigation of Black Males Accessing Community Cultural Wealth and Developing Engineering Attributes*. ProQuest Dissertations & Theses.

Tran, M. C. (2011). *How can students be scientists and still be themselves: Understanding the intersectionality of science identity and multiple social identities through graduate student experiences*. ProQuest Dissertations & Theses.

Tran, M. C., Herrera, F. A., & Gasiewski, J. (2011, April). STEM graduate students' multiple identities: How can I be me and be a scientist. In *National Association of Research on Science Teaching*.

Treisman, U. (1992). Studying Students Studying Calculus: A Look at the Lives of Minority Mathematics Students in College. *The College Mathematics Journal*, 23(5), 362–372. <https://doi.org/10.1080/07468342.1992.11973486>

Triandis, H. C., Chen, X. P., & Chan, D. K.-S. (1998). Scenarios for the Measurement of Collectivism and Individualism. *Journal of Cross-Cultural*

Psychology, 29(2), 275–289. <https://doi.org/10.1177/0022022198292001>

Trinh, M. P., Kirsch, R., Castillo, E. A., & Bates, D. E. (2022). Forging Paths to Interdisciplinary Research for Early Career Academics. *Academy of Management Learning & Education*, 21(2), 318–335. <https://doi.org/10.5465/amle.2019.0386>

Turetsky, K. M., Purdie-Greenaway, V., Cook, J. E., Curley, J. P., & Cohen, G. L. (2020). A psychological intervention strengthens students' peer social networks and promotes persistence in STEM. *Science Advances*, 6(45). <https://doi.org/10.1126/sciadv.aba9221>

Universities & Colleges Admissions Service, Cromar, A., & Green, S. (2000). *Statistical Bulletin on Widening Participation*. UCAS.

Valencia, R. R., & Solórzano, D. G. (1997). Chapter 6 Contemporary Deficit Thinking. In *The Evolution of Deficit Thinking* (1st ed., pp. 160–210). RoutledgeFalmer. <https://doi.org/10.4324/9780203046586-6>

Valenzuela, A. (1999). *Subtractive schooling : U.S.-Mexican youth and the politics of caring*. State University of New York Press.

Vasquez-Salgado, Y., Camacho, T. C., López, I., Chavira, G., Saetermoe, C. L., & Khachikian, C. (2023). “I definitely feel like a scientist”: Exploring science identity trajectories among Latinx students in a critical race theory-informed undergraduate research experience. *Infant and Child Development*, 32(3). <https://doi.org/10.1002/icd.2371>

Vaz, R. F. (2005). Connecting science and technology education with civic understanding: a model for engagement. *Peer Review : Emerging Trends and Key Debates in Undergraduate Education*, 7(2), 13.

Vesterinen, V.-M., Tolppanen, S., & Aksela, M. (2016). Toward citizenship science education: what students do to make the world a better place? *International Journal of Science Education*, 38(1), 30–50. <https://doi.org/10.1080/09500693.2015.1125035>

Vida, M., & Eccles, J. S. (2003, April). Predicting mathematics-related career aspirations and choices. In *Symposium “Antecedents of Mathematics-Related Career Paths and Aspirations: Perspectives from Australia, Canada and the USA”*. Society for Research in Child Development (SRCD) Biennial Conference, Tampa, FL (pp. 24–27).

Villarejo, M., Barlow, A. E., Kogan, D., Veazey, B. D., & Sweeney, J. K. (2008). Encouraging minority undergraduates to choose science careers: career paths survey results. *CBE—Life Sciences Education*, 7(4), 394–409. <https://doi.org/10.1187/cbe.08-04-0018>

Villenas, S., & Moreno, M. (2001). To valerse por si misma between race, capitalism, and patriarchy: Latina mother-daughter pedagogies in North Carolina. *International Journal of Qualitative Studies in Education*, 14(5), 671–687. <https://doi.org/10.1080/09518390110059883>

Watkins, S. E., & Mensah, F. M. (2019). Peer Support and STEM Success for One African American Female Engineer. *The Journal of Negro Education*, 88(2), 181–193. <https://doi.org/10.7709/jnegroeducation.88.2.0181>

Weisgram, E. S., & Bigler, R. S. (2006). Girls and science careers: The role of altruistic values and attitudes about scientific tasks. *Journal of Applied Developmental Psychology*, 27(4), 326–348. <https://doi.org/10.1016/j.appdev.2006.04.004>

Wierenga, M., Heucher, K., Chen, S., Grewatsch, S., & Montgomery, A. W. (2025). Communities for impact: Empowering early-career researchers in the pursuit of impact. *Strategic Organization*, 23(1), 19–30. <https://doi.org/10.1177/14761270241274038>

Wiseman, D., Lunney Borden, L., Beatty, R., Jao, L., & Carter, E. (2020). Whole-some Artifacts: (STEM) Teaching and Learning Emerging from and Contributing to Community. *Canadian Journal of Science, Mathematics and Technology Education*, 20(2), 264–280. <https://doi.org/10.1007/s42330-020-00079-6>

Wynne, B., Jasanoff, S., Pinch, T., Petersen, J. C., & Markle, G. E. (1995). Public Understanding of Science. In *Handbook of Science and Technology Studies* (pp. 361–388). SAGE Publications, Inc. <https://doi.org/10.4135/9781412990127.n17>

Yilmaz, M., Jianhong Ren, Custer, S., & Coleman, J. (2010). Hands-On Summer Camp to Attract K-12 Students to Engineering Fields. *IEEE Transactions on Education*, 53(1), 144–151. <https://doi.org/10.1109/TE.2009.2026366>

Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race, Ethnicity and Education*, 8(1), 69–91. <https://doi.org/10.1080/1361332052000341006>

Young, J. R., Ortiz, N. A., & Young, J. L. (2017). STEMulating interest: A meta-analysis of the effects of out-of-school time on student STEM interest. *International Journal of Education in Mathematics, Science and Technology*, 5(1), 62–74. <https://doi.org/10.18404/ijemst.61149>

Yu, F., Nyanamba, J. M., Anderson, B., DeerInWater, K., Estrada, M., Hosoda, K. K., Maldonado, N., Smith, T., Flores, L., & Hernandez, P. R. (2025). Navigating

science pathways: Belonging mediates the impact of goal congruity on persistence (but not life satisfaction) among Indigenous students. *Journal of Educational Psychology*. <https://doi.org/10.1037/edu0000967>

Zamudio, R. (2015). *From community college to 4-year institutions: Latinas' successful completion of STEM baccalaureate degrees*. ProQuest Dissertations & Theses.

Zaniewski, A. M., & Reinholz, D. (2016). Increasing STEM success: a near-peer mentoring program in the physical sciences. *International Journal of STEM Education*, 3(1), Article 14. <https://doi.org/10.1186/s40594-016-0043-2>

Zwolak, J. P., Dou, R., Williams, E. A., & Brewe, E. (2017). Students' network integration as a predictor of persistence in introductory physics courses. *Physical Review. Physics Education Research*, 13(1), Article 010113. <https://doi.org/10.1103/PhysRevPhysEducRes.13.010113>

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