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Differentiated Career Ecosystems:

Toward Understanding Underrepresentation and Ameliorating Disparities in STEM

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Abstract

Prior work has identified the career ecosystem as a metaphor that represents the multilevel forces influencing individual careers, with the assumption that all individuals experience the ecosystem similarly. We explore how the career ecosystem might be differentiated for different groups of actors within it because of varying cultural and systemic forces. We focus on STEM careers as an exemplar to understand the contextual factors contributing to the low representation and high occupational turnover of women and other underrepresented groups. Based on the career ecosystem metaphor, we develop a multilevel model linking societal, organizational, and occupational cultures with individual career decision making and behavior in the STEM context and show how the resilience of the career ecosystem is different based on gender and racial/ethnic identity. Additionally, we propose ways to interrupt the ecosystem's feedback loop to create a more resilient STEM career ecosystem for women and members of racial and ethnic minoritized groups.

Keywords: career ecosystem, STEM, underrepresented groups, occupational turnover, culture, career decision making and behavior

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Out of 986 total Nobel prize recipients since 1901, 60 have been women (less than 3% of the total). Fifty-nine winners have been from Asia or its diaspora (8 women), and 16 winners have been Black or from the African diaspora (one woman). These statistics underscore that recipients for this prominent award have been overwhelmingly White and male (Wetzel, 2021), and they illustrate a much broader issue across STEM (science, technology, engineering, and mathematics) fields: around the world, women and racial and ethnic minoritized groups[1] are underrepresented. This missing talent is especially problematic at the workforce level because the demand for skilled workers across the STEM labor market is causing a labor shortage (e.g., Iammartino, Bischoff, Willy, & Shapiro, 2016). In Brazil, for example, women account for 45% of the formal workforce, but only 26% of STEM workers (Fernandes, 2021); in Kenya, women are 30-35% of the STEM workforce (Mbirianjau, 2018); in India, women comprise 26% of STEM workers (Malhotra & Gupta, 2022); and in the U.S., women make up 27% of STEM workers (Kantrowitz, 2022). The global STEM talent pool is smaller than it should be.

Given the expected labor shortages in the STEM workforce in the coming years (e.g., Iammartino et al., 2016) and the clear need for more individuals to enter and remain in STEM fields (Fry, Kennedy, & Funk, 2021; Hammonds et al., 2020), it is critical to better understand this phenomenon theoretically to develop a roadmap for further empirical work and sustainable change. We advance a STEM career ecosystem metaphor using the career ecosystems work by Baruch (2015) and Baruch and Rousseau (2019) as a foundation to develop a multilevel, cross-

[1] Throughout this paper, we use the term "minoritized" to reflect social groups that are devalued in society and given less access to its resources as a result. As Sensoy and DiAngelo (2012) note, groups can be devalued by how they are represented, what kind of access to resources they may have, and how the unequal access is rationalized. The term captures the active dynamics that create the perceived/assumed lower status of the group in society.

cultural approach to understanding access, entrance, and occupational turnover out of STEM for women and members of racial and ethnic minoritized groups. Using the metaphor, we develop a testable model with propositions linking culture at the societal, organizational, and occupational levels to individual decision making and behavior in STEM careers and STEM career ecosystem resilience. We postulate that the STEM career ecosystem is different for women and members of underrepresented groups than it is for men and members of dominant groups, and we propose ways to reduce these differences.

This research expands the career ecosystems work of Baruch (2015) and Baruch and Rousseau (2019) in three ways. First, we identify how a career ecosystem is differentiated for different groups of actors within it. In so doing, we refine the work of Baruch (2015) and Baruch and Rousseau (2019) by allowing for a greater understanding of why certain groups experience career ecosystems differently, answering Sullivan and Al Ariss's (2021) call for more research on the career transitions of understudied demographic groups. Second, we extend the concept to be STEM-specific, which is helpful in discerning the unique aspects of the career ecosystem that STEM workers face. Indeed, Inkson et al. (2012), De Vos et al. (2020), and others call for more systematic attention to contextual variables and their influence on individual career decision making and behavior; our focus on a STEM context helps answer this call. Third, we integrate a focus on occupational culture, a critical influence on individual career decision-making that has been understudied within prior work on career ecosystems (Baruch, 2015; Baruch & Rousseau, 2019) and, more generally, organizational scholarship (Dierdorff, 2019).

Definitions and Scope

In keeping with prior research, we define occupations as "collections of work roles with similar goals that require the performance of distinctive activities as well as the application of specialized skills or knowledge to accomplish those goals" (Dierdorff, Rubin, & Morgeson, 2009, p. 974); therefore, individuals are nested within occupations within organizations (Abbott, 1988). We define STEM occupations as those in science, technology, engineering, and mathematics, in addition to those in architecture, information technology, and pharmacy (e.g., Dlouhy & Froidevaux, 2022; Siekmann & Korbel, 2016).

Occupational turnover from STEM fields involves leaving one's occupation or profession (Blau, 2007), which is distinct from leaving one's organization (i.e., organizational turnover; Blau, 2007). Dlouhy and Froidevaux (2022) differentiate between STEM vs. part-STEM (occupations requiring a STEM degree but whose key tasks are not STEM specific—e.g., STEM-related sales or teaching) vs. non-STEM occupations. Our framework focuses on STEM occupations; therefore, we investigate movement into and out of STEM jobs and consider exits from STEM jobs to part-STEM or non-STEM jobs to be occupational turnover. Prior research on occupational turnover suggests that it is a rarer and more difficult transition to navigate than organizational turnover, as there are significantly greater costs to the individual (e.g., possible additional training, disrupted work relationships, and potential lost time and income; Blau, 2007). This underscores the need to better understand why women and underrepresented groups are more likely to experience turnover out of STEM occupations.

In the following section, we review the use of metaphors in the careers literature, integrating prior work on STEM careers. We then extend the career ecosystems metaphor (Baruch, 2015; Baruch & Rousseau, 2019) to STEM careers and use it as a foundation to develop a testable model that unpacks the hierarchical influences of three levels of culture—societal, organizational, and occupational—to better understand the underrepresentation of and higher occupational turnover of women and racial and ethnic minoritized groups out of STEM fields.

Importantly, we do not mean to suggest that the barriers that women and members of racial and ethnic minoritized groups face in STEM careers are only cultural. Many structural issues across the STEM career ecosystem exist, preventing access and success for these groups. The metaphor can be used to develop additional models that focus on other contextual aspects of the ecosystem.

Metaphors in the Careers Literature

Many organizational scientists advocate for the use of metaphors in theory construction (e.g., Cornelisson, 2006; Morgan, 1986; Weick, 1989). Within the careers literature, metaphors are an important part of theory development (e.g., Inkson & Amundson, 2002). Inkson's (2004; 2007) work, for example, identifies nine metaphors in prior literature that have formed powerful images of careers (e.g., career as legacy, construction, journey, theater, story). Another metaphor, the Kaleidoscope Career Model (KCM; Mainiero & Sullivan, 2005; 2006), is somewhat unique among prior career metaphors in that it directly addresses gender differences in careers. As other research suggests, women's careers do not typically represent upward advancement in a single firm, but rather discontinuous employment across multiple employers that is laterally-driven (Mainiero & Gibson, 2018). The KCM model posits the idea that life stage and gender help to prioritize individual needs for authenticity, balance, and challenge over the course of a career, resulting in individual-level decisions to opt-in or opt-out of the workforce. Empirical work based on this model finds that men tend to follow a career pattern that first emphasizes need for challenge, then authenticity, and then work-life integration and balance over time, while women tend to prioritize balance throughout their careers (Mainiero & Sullivan, 2005, 2006).

Within the STEM careers literature, prior research mostly relies on the metaphors of pipelines or pathways to help explain why women and racial and ethnic minoritized groups face unique obstacles in STEM fields (e.g., Lord et al., 2019). Brymer et al. (2019, p. 209) define pipelines as "the sequenced flow and development of individuals repeated over time, disproportionately from specific labor sources into particular positions within firms, occupations, and geographies." The definition includes several salient features, such as repeated and sequenced hiring patterns, the movement and development of workers, and leakage (i.e., when workers exit the pipeline). Used alone, however, the pipeline metaphor is simplistic in its assumptions of directionality (i.e., success entails moving sequentially through the pipeline) and normativity (all individuals proceed through the pipeline in similar ways with equal starting points and access). Moreover, when applied to the underrepresentation and occupational turnover problems in STEM, the pipeline's focus on the supply side of the labor market neglects to account for the complexities that individuals and organizations face in employee career progression and success (e.g., Shore, Cleveland, & Sanchez, 2018). Indeed, numerous interventions to address the leaks in the pipeline have made little difference in outcomes (e.g., van den Hurk, Meelissen, & van Langen, 2019), perhaps because the metaphor itself encourages a simplistic emphasis on "flow," or solely on the numbers of members of underrepresented groups entering STEM fields.

The pathways metaphor is more nuanced than the pipelines metaphor and provides an alternative understanding of how individuals may progress through critical career decision points as they decide to engage in STEM fields (e.g., Servon & Visser, 2011). The metaphor acknowledges that individuals may have to overcome barriers to access resources and progress in their careers as they consider a variety of entry points into a given career. However, as Lord et al. (2019, p. 34) note, the pathways metaphor does not comprehensively address "what happens *on* the paths [in STEM]—the extent to which some paths are smooth, some well-worn, some rocky;" the pathways model also does not address the reasons for exits from the pathways (e.g., institutional climate and practices, social expectations, and individual perceptions of inclusion; Shore et al., 2018). Therefore, the pathways metaphor also falls short of providing a holistic picture of the career challenges of women and underrepresented groups in STEM fields.

The ecosystem metaphor, originally developed in the field of ecology (Golley, 1993; Tansley, 1935), has existed in the organizational sciences for some time (e.g., Iansiti & Levien, 2004), but its application in a careers/labor market context has been relatively recent (e.g., Baruch, 2015; Baruch & Rousseau, 2019), and it has not yet been extended into the STEM careers literature. Broadly defined, an ecosystem is a "system that contains a large number of loosely coupled (interconnected) actors who depend on each other to ensure the overall effectiveness of the system" (Iansiti & Levien, 2004, p. 5). Ecosystems can be considered as a specific type (or subset) of systems, which include living organisms and the physical environment as a complex, integrated whole (Tansley, 1935). Baruch (2015, p. 365) defines the more specific concept of the career ecosystem as "a metaphorical use of the natural science ecosystem concept… in which the organisms are replaced by human beings, and the physical environment is replaced by a complex system of labor markets" that include organizations and institutions of all types (i.e., ranging from small-large, private-public, local-global).

The main actors in the career ecosystem are individuals, organizations, and nations/societies (Baruch, 2015). Because career ecosystems include all three actors as focal points, they allow for a bridging of the disconnect between individual perspectives on career choice and success, the organizational/managerial perspective (Baruch, Altman, & Tung, 2016), and contextual factors such as societal culture and systemic/institutional bias. Baruch (2015) describes how all levels of the career ecosystem (individual, organizational, and societal) coexist and interact with each other, learning from these interactions, and exhibiting dynamism and flexibility as the needs of the entities within the ecosystem evolve and change.

Following the work of Iansiti and Levien (2004), who identify three dimensions of health for business ecosystems (productivity, robustness, and niche creation), Baruch and Rousseau (2019) propose three types of career ecosystems, as defined by varying levels of resilience and adaptability (i.e., the capacity to continue or prosper in the face of environmental uncertainty). Fragile career ecosystems (low resilience) are those that include limited employment opportunities, more stress for workers, a sparse and unequally distributed network, a clear hierarchy for winners with limited career opportunities for others, and individual compensation deals reserved and allocated non-transparently for those with high status. In these ecosystems, psychological contracts are short-term, exchange-oriented employment arrangements, rather than longer-term investments between the individual and organization that reflect balance and mutual support (Baruch & Rousseau, 2019).

In contrast to fragile career ecosystems, both robust and anti-fragile career ecosystems allow for more individual agency within career decision-making. Robust career ecosystems (medium resilience) include opportunities for self-directed careers within a single organization and serial employment opportunities thereafter, employment protections for workers, trade unions, relatively relational/balanced psychological contracts, and moderate access to financial and developmental resources. Anti-fragile career ecosystems (high resilience) involve supportive environments with many sources of financial, personal, and developmental resources and opportunities for individuals to seek boundaryless careers (i.e., careers characterized by physical and psychological mobility, in addition to individual agency with respect to career development responsibilities; Arthur & Rousseau, 1996). Additionally, these career ecosystems include network ties that allow for more career prospects outside the context of a single organization (Baruch & Rousseau, 2019); the broad and diverse network ties that individuals in this type of career ecosystem develop can allow individuals to access numerous career opportunities (Granovetter, 1973; 1995). The concept of career ecosystem resilience is different from the concept of career resilience (first proposed by London, 1983). The former takes a holistic, systemic perspective on career labor markets, while the latter traditionally emphasizes individual ability, persistence, and development with respect to one's career despite obstacles and setbacks (Mishra & McDonald, 2017).

Baruch and Rousseau (2019) assume that the resilience and adaptability of the career ecosystem is experienced similarly by all individuals within it (with the exception of "social isolates and those less proactive or agentic," p. 97). They provide the example of the post-financial crisis employment situation in Greece to illustrate a fragile ecosystem, while high technology clusters in Silicon Valley, China, and Argentina are illustrative of anti-fragile ecosystems. In contrast, we contend that the STEM career ecosystem is likely experienced in dissimilar ways at the individual level because contextual and systemic forces affect individuals differently based on their gender and race/ethnic identity.

The STEM Career Ecosystem: Metaphor and Model

The STEM career ecosystem is a subsystem of the general career ecosystem and represents the specific career ecosystem for individuals in STEM fields. Within this ecosystem, individual actors (i.e., members of the STEM workforce) are nested within their occupations, departments, and organizations. Individuals are influenced by the structural and cultural features of these contexts. The organizations themselves are nested within a broader industry space that includes a range of stakeholders, including competitors, academic institutions, non-profit and professional organizations, governmental regulatory bodies, suppliers, and customers. This industry space both serves as an influence on and is influenced by occupational culture. Additional systems that overlap with the STEM career ecosystem (e.g., the elementary and secondary education systems, the higher education system, and the workforce development system) also exert influence on the STEM career ecosystem's stakeholders. Another layer of nesting occurs at the level of societal culture; while the STEM industry is global, actors within a given STEM career ecosystem are influenced by societal culture (e.g., House, Hanges, Javidan, Dorfman, & Gupta, 2004).

Across the STEM career ecosystem metaphor, top-down influences, where systems and structures at higher levels of analysis impact and constrain lower-level entities, and bottom-up influences, where individual actors (or groups of them) can impact the broader system, are critical. In addition, bi-directional interactions reinforce existing aspects of the ecosystem. Over time, the ecosystem perpetuates itself, as interactions between entities in the ecosystem are predictable and self-reinforcing. Ultimately, those who find the ecosystem to be anti-fragile or robust remain; those who find the ecosystem to be fragile and who would most benefit from systemic changes to the environment exit the ecosystem.

The impact of culture on the STEM career ecosystem

Here, we consider the hierarchical influence of three levels of culture—societal, organizational, and occupational—as contextual forces on individual career decision-making and behavior. We argue that all three levels of culture push women and underrepresented racial and ethnic minoritized groups away from STEM fields, both before and after entrance into these occupations, resulting in dissimilar levels of STEM career ecosystem resilience experienced by different social identity groups. Importantly, while these cultural forces affect all STEM fields, some STEM fields may be more affected than others (Cheryan et al., 2017).[2] The model is depicted in Figure 1. We draw from Schneider's (1987) attraction-selection-attrition (ASA) mechanism to help explain this process.

Insert Figure 1 about here

Levels of culture as a contextual influence

The career ecosystem metaphor draws attention to contextual influences on individuals. Prior research on careers (e.g., De Vos et al., 2020) and career transitions (e.g., Sullivan & Al Ariss, 2021) note the existence of societal culture as a contextual influence on individual agency with respect to career choice, but this literature has not yet thoroughly integrated culture as a higher-level influence on individual career decision-making. A society's culture is deeply entrenched and shapes academic institutions, organizations, occupations, and individuals. We define societal culture in line with the work of House et al. (2004, p. 15), as "shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives that are transmitted across age generations." Building on Hofstede (1980; 2001) and others, House et al.'s (2004) work on societal culture identifies nine dimensions of culture. While many of the dimensions could impact the STEM career ecosystem, we focus here on one dimension of societal culture that is highly salient for women: gender egalitarianism.[3] The gender egalitarianism dimension of culture "reflects

[2] Cheryan et al. (2017), for example, find larger gender gaps in student participation across education levels for computer science, engineering, and physics than for biology, chemistry, and mathematics. Additionally, they find that the proportion of women students declines at different rates for different STEM fields, suggesting that different educational recruitment and retention strategies are necessary based on specific STEM field.

[3] Gender egalitarianism as a cultural dimension in GLOBE is an outgrowth of Hofstede's (1980; 2001) masculinity-femininity dimension of culture. Hofstede (1980; 2001) identifies more feminine cultures as those that are more

societies' beliefs about whether members' biological sex should determine the roles that they play in their homes, business organizations, and communities" (Emrich, Denmark, & Den Hartog, 2004, p. 347).[4]

This dimension of culture has received very limited attention in management research (Nadeem & Sully de Luque, 2020), but it clearly influences the STEM career ecosystem. Societies that are more gender egalitarian are likely to be societies that cultivate a more welcoming environment for the exploration of science, technology, engineering, and math for girls and women from birth. These societies are likely to invest more in educational opportunities for girls and are more likely to support and nurture their interests in diverse subject matters. As one example, a comparatively high level of gender egalitarianism practices in Russia (Grachev, 2009) has resulted in a history of participation among women in STEM fields (Bullock, 2017). We suggest here that gender egalitarianism cultural practices are related to the extent to which stakeholder systems support girls and women in the pursuit of STEM careers, such that in societies with higher levels of gender egalitarianism practices, stakeholder systems will be more supportive of girls and women in STEM.

The STEM career ecosystem metaphor prompts the inclusion of two additional levels of culture as contextual influences on individuals: organizational and occupational culture. As Dierdorff (2019, p. 411) notes, "Individuals live in occupations, and occupations live in organizations." For its part, organizational culture - as a pattern of shared assumptions, values,

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nurturing, less assertive, less performance-oriented, and with less emphasis on traditional gender roles and gender differences. The GLOBE study separates various aspects of Hofstede's masculinity/femininity dimension into more specific cultural dimensions and classifies gender egalitarianism as its own dimension of culture.

[4] Around the world, relatively high levels of gender egalitarianism reflect less emphasis on patriarchy. In their study of gender egalitarianism across 62 cultures, Emrich et al. (2004) find that no society perceives itself to be female dominated to the point of encouraging girls to attain higher education more than boys, for example. They conclude that across cultures, there is a reliance on biological sex in the allocation of gender roles.

beliefs, and norms - influences the behavior of individuals within organizations (e.g., Schein, 1990; 2004), but it is also influenced by societal culture. House et al.'s (2004) work suggests that gender egalitarianism as a cultural dimension can be meaningfully measured and interpreted at the organizational level. Emrich et al. (2004) find that societal gender egalitarianism is significantly and positively related to organizational gender egalitarianism. In other words, societies with practices and values reflecting greater gender egalitarianism influence the organizations within them to be more gender egalitarian. As part of the STEM career ecosystem metaphor's interconnectedness among levels, we expect that organizational cultures may also influence societal cultures, resulting in bi-directional influence between the two levels of culture.

With respect to occupational culture, because occupations are socially constructed, they require consensus around the tasks, values, and behavioral expectations associated with work roles (Abbott, 1988; Dierdorff, 2019; Trice, 1993). As a result, occupations serve as contexts with their own cultural features. Prior research has identified occupational culture as a unique lens through which individuals interpret organizational events (Van Maanen & Barley, 1984), serving as an important and distinct subculture within work organizations (Barley, 1983; Dierdorff, 2019; Trice, 1993). These subcultures are characterized by domains of expertise and, through formal mechanisms such as education, certifications, and apprenticeships, exert authority and legitimacy over abstract and specific knowledge (Dierdorff, 2019). In the case of STEM fields, occupational culture has largely been identified as masculine (i.e., excessively competitive with an emphasis on traditional gender roles; e.g., Servon & Visser, 2011). Cheryan et al. (2017) find that the STEM fields of computer science, engineering, and physics are particularly characterized by an occupational cultural environment that confers a greater ability to succeed and a greater sense of belonging to men than women.

The STEM career ecosystem metaphor encourages the consideration of the cumulative effects of these three levels of culture on individuals. Schneider's (1987) attraction-selection-attrition (ASA) model provides further insights into what may happen for women as they encounter levels of culture in STEM fields. Briefly, Schneider (1987) identifies that personal characteristics draw individuals toward certain organizations and causes those organizations to select them as new hires. Ultimately, individuals who do not fit in with the organization's culture will leave. As a result of this process, organizations move toward member homogeneity, which "consequently defines the nature of the organization, its structures, processes, and culture" (Schneider, Goldstein, & Smith, 1995, p. 748). We note that fit between the individual and the organization in the ASA model has typically focused on the personality characteristics of the individual (e.g., Ployhart, Weekley, & Baughman, 2006; Schaubroeck, Ganster, & Jones, 1998), although Schneider et al. (1995) point out that the ASA theory is vague with respect to what "personal characteristics" might be involved. Additionally, Schneider and his colleagues suggest that the effects of the ASA model extend to occupation (e.g., Schneider, 1987; Schneider et al., 1995), causing both organizations and occupations to become more homogenous over time. Schaubroeck et al. (1998) find empirical support for this when considering personality as an individual characteristic, concluding that personality homogenization is further amplified within particular occupational subgroups within organizations.

Building from the above arguments and ASA theory, we postulate that gender is a personal characteristic that is salient across all three levels of culture in STEM fields. Women may be less attracted to STEM fields because of a perceived mismatch between their gender and these occupations across societal, organizational, and occupational culture. Around the world, because STEM fields are traditionally masculine spaces (e.g., Cheryan et al., 2017; Servon &

Visser, 2011), girls and women are more likely to have to push back against cultural expectations to engage in a STEM career (e.g., Guo, Marsh, Parker, Dicke, & Van Zanden, 2019). For their part, organizations and occupations (and the people within them) are less likely to select women into STEM positions because of this perceived mismatch. When women do make it through the hiring process and begin careers as STEM professionals, the tension between their gender and occupation at all three cultural levels makes them more likely to leave the STEM career ecosystem altogether.

Although no research to our knowledge has developed a specific dimension reflecting the extent to which a given societal, organizational, or occupational culture favors dominant racial and ethnic groups, we suspect that this aspect of culture may also be influencing minoritized individuals in the STEM career ecosystem in a cumulative way. In societal cultures that heavily favor dominant groups, individuals with minoritized backgrounds will not have the same opportunities to enter STEM fields. As one concrete example, from the start of its history as a nation, the U.S. government devalued indigenous people and their cultures. As a result, school systems on reservations for Indigenous American groups in the United States are undervalued and underfunded (e.g., Huffman, 2010), making it harder for these students to attain the academic background necessary to attend college or study STEM fields (Tsui, 2007). Organizational cultures will, to some extent, reflect the practices and values of the societal cultures within which they are nested (e.g., House et al., 2004), favoring dominant groups and undervaluing racial and ethnic minoritized groups.

For their part, STEM occupational cultures are often not inclusive places for minoritized individuals (Tsui, 2007). Indeed, members of racial and ethnic minoritized groups in STEM fields face negative stereotypes (Eaton et al., 2020), workplace discrimination (Hall et al., 2017;

Saw et al., 2018), and a low sense of belonging, cultural isolation, and self-doubt (e.g., Byars-Winston, 2014; Dlouhy & Froidevaux, 2022). Following the ASA model logic, we expect that non-dominant race and ethnicity are personal characteristics that conflict with the three levels of culture within STEM fields. Indeed, Williams et al. (2023) use the ASA model as a theoretical framework to understand the importance of race as a personal characteristic of Black physicians as they navigate racism in the healthcare system, finding that the theory is robust in consideration with race as an individual characteristic.

In sum, three levels of culture—societal, organizational, and occupational—have a cumulative effect on individual career decision-making and behavior, which differs based on gender and racial/ethnic identity. Although there is some variability in terms of occupational culture and gender representation across STEM fields (e.g., Cheryan et al., 2017), these three levels of culture indirectly influence STEM higher education and workforce participation for women and members of racial and ethnic minoritized groups and ultimately create a differentiated STEM career ecosystem with differing levels of adaptability and resilience for different social identity groups.

Implicit theories of STEM as a linking mechanism

As a multilevel metaphor, the STEM career ecosystem encourages cross-level theoretical connections. We propose that individual-level implicit theories (i.e., knowledge structures; Hanges, Lord, & Dickson, 2000; Schein, 1990) serve as linking mechanisms between the contextual and individual levels. Implicit theories are defined as the basic beliefs that help individuals organize their world and guide their behavior (Dweck, 2012). We posit that implicit knowledge structures regarding STEM fields and careers exist, which we term implicit theories of STEM. These knowledge structures include beliefs about (1) Who is allowed to/should participate in STEM; (2) Why they might participate; and (3) What kind of resources are necessary to participate in STEM. Societal, organizational, and occupational cultures work in tandem to influence individual-level implicit theories of STEM, which in turn reinforce the reality of access to, entrance into, and turnover out of the STEM career ecosystem for individuals with different social identities.

With respect to the first set of implicit beliefs—who is allowed to/should participate in STEM fields—cultural expectations, stereotypes, and early educational experiences play an important role. Scientists, engineers, and other STEM professionals have traditionally been depicted as men from dominant racial or ethnic groups (e.g., Nguyen & Riegle-Crumb, 2021). These representations support and perpetuate existing stereotypes of STEM professionals. In the U.S., for example, the shifting standards model (Biernat & Kobrynowicz, 1997) demonstrates the negative impact of cultural expectations for both women and individuals who identify as Black. Prior research finds that although both groups are held to lower minimum standards (i.e., less is expected of them to meet minimum thresholds for basic competence), they are simultaneously held to a much higher standard of ability (i.e., the amount of skill necessary for performing a job). Thus, the cultural expectation is that women and individuals who identify as Black are less competent (but just competent enough to do a given job), but to be evaluated as *capable* (i.e., excelling or succeeding at a job), women and individuals who identify as Black must demonstrate much greater ability and skill levels than men or White people (Biernat & Kobrynowicz, 1997). This is particularly damaging in certain STEM fields, where stereotypes can be especially prevalent. Cheryan et al.'s (2017) model suggests that in the U.S., stereotypes about people in specific STEM fields, negative stereotypes about women's abilities, and the overall lack of female role models result in lower representation of women in computer science, engineering, and physics. Moreover, these stereotypes, when combined with the fact that pre-college students in the U.S. receive less exposure to some STEM fields than others, result in the underrepresentation of women in these fields (Cheryan et al., 2017) and likely contribute to the implicit beliefs about who is allowed to/should participate.

The second set of beliefs about STEM involves why individuals might participate in these fields, or the underlying motivation for pursuing a STEM career. As Tsui (2007) reviews, parental attitudes and legacy career effects differ between racial/ethnic social identity groups. In the U.S., parental influence exerts a greater impact on Black and Indigenous American high school students as compared to White students (Tsui, 2007), and parents who identify as members of racial and ethnic minoritized groups are less likely to be in STEM fields themselves, given the historic underrepresentation of these groups in STEM (Tsui, 2007). While these differences were observed in U.S.-based samples, family influences on individual STEM career decisions and behavior are likely different based on social identity, regardless of location. Additionally, widespread societal beliefs persist that STEM careers do not promote communal values like altruism and affiliation. For many women, these values are important in career choice decisions (Diekman, Brown, Johnston, & Clark, 2010). In any case, prior research has found that young women report being less likely to value careers in basic science and mathematics (Diekman et al., 2010; Grunert & Bodner, 2011; Valenti, Masnick, Cox, & Osman, 2016).

The third set of implicit beliefs about STEM involves what kind of resources are necessary to participate in STEM, which includes where STEM and STEM- preparatory work happens and the accessibility of these places. Highly technical STEM work is often associated with world-class, socially isolated laboratory facilities, which are expensive and seemingly inaccessible (e.g., Valenti, et al., 2016). Despite efforts promoting STEM in the kitchen (e.g., the

National Education Association's "STEM Lessons in the Kitchen" website) and other common environments, we conjecture that implicit beliefs about STEM and STEM-preparatory equipment and space involve inaccessibility and high barriers to entry (e.g., cost). Indeed, Cheryan et al.'s (2017, p. 6) work suggests that early educational experience in the U.S. is an important antecedent of who participates in STEM activities; early exposure to STEM subjects in the classroom may help shape implicit beliefs regarding the resources necessary to participate.

Implicit knowledge structures are malleable and can be influenced by a variety of situational factors. House et al. (2004) find that societal culture influences implicit theories of leadership (Lord & Maher, 1991). Similarly, we postulate that culture influences individual-level implicit theories of STEM, which in turn serve as a linking mechanism across levels of analysis to explain the effects of culture on individual career decision-making and behavior with respect to STEM fields. STEM higher education and workforce participation, at an aggregated level, will be affected accordingly. Therefore, in societies that are high on gender egalitarianism practices, gender roles and stereotypes are less pervasive, implicit theories regarding STEM may be more inclusive, and girls and women may be more likely to feel they belong in STEM careers. Organizations in these societies are also likely to be high on gender egalitarianism practices (e.g., Emrich et al., 2004) and more supportive of the presence of women in STEM fields, reinforcing the inclusiveness of the implicit theories. At the occupational level, in STEM fields where stereotypes are less negative regarding women's participation and the culture is less masculine (e.g., Cheryan et al., 2017), implicit theories of STEM will be more inclusive of girls and women. Similarly, in societies, organizations, and STEM occupations that favor dominant racial and ethnic groups less and value minoritized groups more, more inclusive implicit theories of

STEM may exist. These implicit beliefs will influence individual career decision-making and behavior, which will ultimately impact STEM higher education and workforce participation.

> *Proposition 1:* Societal, organizational, and occupational culture will influence individual STEM career decisions and behaviors, and STEM higher education and workforce participation, through influencing individual-level implicit theories of STEM.

From individual STEM careers to STEM career ecosystem resilience

Entities in ecosystems display complex interdependencies, as they are interrelated and mutually influence each other (Baruch, 2015; Iansiti & Levien, 2004). Individual STEM career decision-making and behavior has a bottom-up influence on the rest of the STEM career ecosystem that serves to reinforce the layers of cultural influences we describe above, creating a feedback loop. We propose here that aggregated STEM career decision-making and behavior for different social identity groups, and the closely-related phenomena of STEM higher education and workforce participation for these groups, directly influence the resilience of the STEM career ecosystem (i.e., fragile, robust, or anti-fragile) for these groups. This results in a career ecosystem that is differentiated for different groups of actors within it.

Men who are members of dominant racial/ethnic groups in STEM careers (and those who are considering STEM careers) may experience the resilience of the STEM career ecosystem as medium to high (i.e., robust or anti-fragile), because so many others like them are making career decisions to enter, and stay within, the STEM career ecosystem. The higher rates of participation relative to other social identity groups reinforce individual-level implicit theories of STEM, particularly with respect to who is allowed to/should participate; the social identities of these individuals are congruent with others' expectations of professionals in their fields. Additionally, the legacy of representation for men who are members of dominant racial/ethnic groups in professional networks within STEM allow them to progress within the ranks of a single organization or to move across the ecosystem to seek better opportunities within the same occupation with other STEM organizations. As Baruch and Rousseau (2019) note, anti-fragile ecosystems are supportive environments, rich with resources and opportunities for individuals to exert the privilege of agency and seek boundaryless careers (Arthur & Rousseau, 1996). Robust career ecosystems also allow opportunities for self-directed careers, along with other advantages such as moderate access to structural, financial, and developmental resources. Baruch and Rousseau (2019) also note that these career ecosystems include well-developed network ties that enhance career prospects across organizations within the same occupation leading to numerous career opportunities (Granovetter, 1973; 1995). As a result, for men who are not members of racial or ethnic minoritized groups, the resilience of the STEM career ecosystem is likely to be robust or anti-fragile, and their occupational turnover low.

In contrast, for women and members of racial and ethnic minoritized groups, relatively low rates of participation in STEM careers may confirm individual-level implicit theories of STEM, and the resilience of the STEM career ecosystem is more likely to be low (i.e., fragile). Fragile STEM career ecosystems involve a more stressful, short-term oriented set of career opportunities, with poorly-developed and unequal networks, clear hierarchies for winners and limited career opportunities for others (Baruch & Rousseau, 2019). Indeed, underrepresented groups experience more hostile work environments and barriers to career progression in STEM fields (e.g., Lee et al., 2020). Their personal networks may be less developed due to constraints specific to their minoritized identities, and opportunities to advance within the STEM ecosystem may be more limited. These underrepresented groups may not have the same kind of agency within the STEM career ecosystem as men who are members of dominant groups; they may not experience the same kinds of "boundaryless career" opportunities within the STEM ecosystem that members of powerful groups have, because fragile STEM career ecosystems do not have the resources to allow for individual agency within a given STEM occupation.

> *Proposition 2:* The resilience of the STEM career ecosystem as experienced by members of different social identity groups is dependent on the participation of group members within the STEM higher education system and workforce, such that higher participation rates are associated with greater resilience, and
>
> (a) Men who are not members of racial and ethnic minoritized groups experience the STEM career ecosystem as robust or anti-fragile.
> (b) Women and members of racial and ethnic minoritized groups experience the STEM career ecosystem as fragile.

The STEM career ecosystem feedback loop and ecosystem differentiation

The systemic forces influencing different social identity groups interact and self-reinforce over time, as the ecosystem perpetuates itself and those who experience the ecosystem as fragile exit the ecosystem altogether. More specifically, if women and members of racial and ethnic minoritized groups experience the resilience of the STEM career ecosystem as fragile, they will be more likely to seek another career outside of STEM, thus increasing occupational turnover for these groups. As more professionals from these underrepresented groups leave or are pushed out and professionals from dominant groups continue to succeed, the differentiated ecosystem solidifies, and there is little motivation among those from dominant groups to alter systems and practices to be more inclusive and welcoming to underrepresented group members (e.g., De Souza & Schmader, 2021; Glazer & Liebow, 2021). The forces in the STEM career ecosystem therefore create a self-reinforcing cycle, leading to higher levels of occupational turnover for women and racial and ethnic minoritized groups over time.

> *Proposition 3.* The interrelationships among entities in the STEM career ecosystem form a feedback loop, in which the resilience of the ecosystem for different social identity groups further solidifies the inclusion/exclusion of these groups and the differentiation of the ecosystem over time.

Interrupting the feedback loop to improve STEM career ecosystem resilience

Without intervention, the STEM career ecosystem will continue to be differentiated: anti-fragile or robust for men who are not members of racial and ethnic minoritized groups and fragile for women and members of racial and ethnic minoritized groups, making it harder for these individuals to choose STEM careers and creating higher levels of occupational turnover for those who do. The proposed set of relationships, however, illuminates opportunities for entities within the STEM career ecosystem to engage actively and strategically in processes that will positively impact the resilience of the ecosystem for all individuals within it.

Societies, organizations, and professional organizations affiliated with STEM occupations could begin by engaging in strategic workforce and human capital development practices that are targeted toward the shared goal of strengthening the labor force. An understanding of the cultural and systemic forces impacting women and members of racial/ethnic minoritized groups in the STEM career ecosystem must inform these practices. This could then serve as a foundation for culture change and improved resilience in the STEM career ecosystem as experienced by all individuals.

At the societal level, elements such as the elementary, secondary, and higher education systems influence the domestic supply of STEM talent (e.g., Tsui, 2007). Education systems that include early, high-quality, and comprehensive STEM experiences for all students will help boost participation by girls and children who are members of racial and ethnic minoritized groups (Cheryan et al., 2017). Moreover, anecdotal evidence suggests that given the unique set of challenges these students face, high-quality programs more specifically targeted towards them are critical.[5] Other targeted governmental workforce and human capital development programs

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[5] We thank an anonymous reviewer for pointing us in the direction of the work of Girls4STEM at the Escola Tècnica Superior d'Enginyeria de la Universitat de València in Spain as an example. This group helps to create support

can also boost STEM participation for underrepresented groups. As one example, the European Union launched Women TechEU, which supports 50 women-led tech startups with a budget of €3.8M; as another, in the U.S., the National Science Foundation has provided $270M since 2001 to higher education institutions and STEM-related non-profit organizations through ADVANCE grants to increase the representation and advancement of women in academic science and engineering careers. These kinds of programs are helpful, but bundling efforts in a strategic way as a set of practices across a given society is most likely necessary to create a lasting impact. This will require both resources and political will.

At the organizational level, strategic human resource development practices (i.e., those that focus on the long-term development of human resources in organizations, aligned with strategic goals; e.g., Garavan, 2007) are critical. There is some empirical evidence that a targeted strategic approach to developing human capital using diversity, equity, and inclusion (DEI) practices is related to greater DEI outcomes. Konrad, Yang, and Maurer (2016), for example, find that diversity and equality management systems, when deployed as bundles of practices that are vertically linked to organizational strategy, are positively related to the numbers of people with disabilities and "visible" minoritized group members employed by the organization. While climate for inclusion and equity issues are also important for these organizations to consider, this finding suggests that organizations can assemble a targeted, strategic approach to develop human capital in STEM fields by working intentionally to become more inclusive and equitable places. Indeed, as Baruch and Rousseau (2019) note, organizations and their human resource strategies can be used to improve the experiences and status that workers have in relation to others. We

networks for STEM students by matching them with women scientists and engineers as mentors (see Benavent et al., 2020, for more details).

conjecture that organizations that emphasize and support women and members of racial and ethnic minoritized groups in STEM fields as a deliberate part of their strategic human resource development practices will ultimately create positive change with respect to organizational culture and climate for inclusion.

At the occupation level, professional organizations play a key role in supporting STEM workers who identify as members of underrepresented groups. In the U.S., the efforts of non-profit groups like the Association for Women in Science (AWIS), the Society for Women Engineers (SWE), the American Indian Science and Engineering Society (AISES), and the National Society of Black Engineers (NSBE) are critical in providing professional development and support networks for historically underrepresented groups. Additionally, groups like MOSAIC (Members of Society Advancing an Inclusive Culture) embedded within the American Society of Civil Engineers (ASCE) provide leadership on all DEI matters within their broader organization. Again, we conjecture that the more intentionally strategic these kinds of efforts are, and the more they bundle multiple diversity management practices together with effective outreach to other stakeholder systems, the greater the chances of being able to interrupt the feedback loop of the STEM career ecosystem. Over time, we postulate that the resilience of the ecosystem as experienced by women and members of racial and ethnic minoritized groups will improve as a result.

> *Proposition 4.* The deployment of strategic workforce and human capital development practices with the shared goal of strengthening the STEM labor force across societal, organizational, and occupational levels can interrupt the feedback loop by influencing culture and can allow for members of all social identity groups to experience the STEM ecosystem as robust or anti-fragile.

Discussion

We advance the use of a career ecosystem metaphor to understand and ameliorate the disparities women and members of racial and ethnic minoritized groups in STEM face. We use the STEM career ecosystem as an exemplar to highlight contextual, cross-level influences on individual career choice and behavior. The model we develop from the metaphor introduces implicit theories of STEM as a mechanism linking three levels of culture (societal, organizational, and occupational) to individual STEM career decision making and behavior. These forces cause different social identity groups to experience different levels of ecosystem resilience, ultimately creating a differentiated ecosystem for these groups and influencing group member decisions to remain within or leave the STEM career ecosystem. The metaphor and model help explain the phenomena of low representation and high turnover in STEM careers for women and members of racial and ethnic minoritized groups and provide an opportunity to consider actionable solutions to boost the ecosystem's resilience.

Implications for research

We have focused our ideas on the STEM context, but the broader point that a career ecosystem can be differentiated for different groups of actors within it is a critical contribution and implication of our work. Because systemic and contextual forces affect members of various demographic groups in dissimilar ways, the resilience of the career ecosystem is different for individuals based on their social identity. STEM fields are not alone in terms of underrepresentation of women and members of racial/ethnic minoritized groups. Many other fields (e.g., law, finance, firefighting, law enforcement, cinematography, etc.) also grapple with underrepresentation of different social identity groups and likely also contain differentiated career ecosystems. Future work could explore the extent to which challenges faced by women and members of racial/ethnic minoritized groups are unique to a given type of career ecosystem or whether they are more widespread; the lessons learned could reduce the differentiation in career ecosystems and improve access and entrance into these careers while reducing occupational turnover for these groups.

Our work also has implications for the literature on STEM careers. While others have examined the occupational turnover of women and underrepresented ethnicities from STEM fields empirically (e.g., Dlouhy and Froidevaux, 2022), the literature on STEM careers has lacked comprehensive theoretical development. Concurrently, in the broader careers research area, prior work has identified the importance of—and lack of attention to— contextual issues that influence individual agency during the career decision process (e.g., De Vos et al., 2020; Inkson et al., 2012; Sullivan & Al Ariss, 2021; Sullivan & Baruch, 2009). Our research helps to address these gaps. We use the ecosystem metaphor to develop theory focused on the impact of societal, organizational, and occupational culture on women and members of racial and ethnic minoritized groups; the metaphor can be used in future research to develop testable models that focus on other aspects of the ecosystem both for STEM careers and more broadly.

We introduced a novel concept to link culture and individual career decision-making and behavior in STEM: individual-level implicit theories of STEM. Future empirical research could develop a measure of this concept, focusing on the three categories of beliefs we identified above. Once the measures are validated, they could then be used in empirical cross-cultural STEM career studies. If this concept is as central as indicated by our theoretical model, it will be important for future work to examine more carefully the role cultural practices and values at the societal, organizational, and occupational cultures may play in impacting these beliefs. Also, it will be important to understand whether moderating factors exist, and if so, whether they may be possible leverage points to change these beliefs to create opportunities for the next generation of STEM workers.

To test the propositions involving STEM career ecosystem resilience, social network analysis (e.g., Freeman, 2004) could be used to examine the extent to which different social identity groups experience the STEM career ecosystem as fragile, anti-fragile, or robust. Management scholars and organizational theorists have highlighted the extent to which mainstream research assumes neutrality with respect to gender and race (e.g., Ainsworth & Pekarek, 2022; Ray, 2019). Evidence-based results from this line of research could help challenge this assumption and inform future work.

Implications for practice

Identifying that the STEM career ecosystem is fragile for women and members of racial and ethnic minoritized groups is just a first step in terms of moving toward systemic change. We also advocate for a strategic workforce and human capital development perspective in attempting to interrupt the current status quo of the ecosystem. Bundles of human capital development practices deployed in a strategic and intentional way across the societal, organizational, and occupational levels will be necessary. Within organizations, strategic HR practices with the goal of improving the resilience of the STEM career ecosystem for all individuals in STEM careers must cascade from the commitment of top leadership to create positive change in career opportunities and trajectories. Additionally, these practices should include attention to developing vision, mission, and strategy that includes DEI considerations; support for recruitment and retention efforts for members of underrepresented groups; attention to training and development of new and existing employees; and efforts to understand and improve climates for diversity and inclusion.

At the societal level, this could begin to manifest as strong rhetoric from national leaders supporting educational efforts, inclusion, and resource commitment in STEM fields for women and underrepresented groups. Additionally, countries that have higher levels of participation for women and racial and ethnic minoritized groups in STEM fields can serve as models for other societies in terms of encouraging inclusive policies and practices in STEM. At the organizational level, top leaders must be committed to positive change with respect to the inclusion of women and racial and ethnic minoritized groups in STEM; while research on this is scarce in STEM fields, one recent study finds that CEOs' diversity-valuing behavior reduced turnover for women executives (Dwivedi, Gee, Withers, & Boivie, 2022). With that commitment, the organization's vision, mission, and strategy should adjust accordingly, resulting in strategic efforts to align existing HR practices and build new HR architecture where necessary to support the organization's vision around building a more inclusive and resilient STEM career ecosystem for its employees.

At the occupational level, leadership groups of professional organizations must examine their priorities and practices to ensure that the concerns of women and racial and ethnic minoritized groups are heard and addressed and that bundles of strategies are developed, in tandem with industry and government, to create positive change and make STEM fields more inclusive. As we have noted, some STEM fields do have higher levels of participation for women and racial and ethnic minoritized groups; there may be important takeaways from them. Cheryan et al.'s (2017) findings regarding the STEM fields in the U.S. with the least gender differences in participation (i.e., biology, chemistry, and mathematics) suggest it is important for societies to make other STEM fields commonplace and required in high school. Additionally, insufficient exposure and early educational opportunities for girls to get involved in computer science, engineering, and physics may contribute to higher gender gaps in self-efficacy and the more masculine occupational cultures in these fields (Cheryan et al., 2017). Indeed, in the U.S., 48.6% of working biologists are women, while they make up just 31.5% of research chemists (stats from careers website Zippia.com). Beyond the realm of education, other governmental policies and strategies have already been implemented around the world to try to address the shortage of women in STEM fields (e.g., UNESCO, *Cracking the Code*, 2017)—these efforts could be studied as additional leverage points to build the resilience of the STEM career ecosystem.

While this is an ambitious agenda, it is important to note that these efforts can lead to positive outcomes for organizations. For example, Michels, Murphy, and Venkataraman (2023) find that investing in diversity, equity, and inclusion efforts to build talent can help organizations prepare for growth and build capabilities for learning and change. Other scholarship draws the link between diversity management practices, firm financial performance, and corporate social responsibility (e.g., Srikant, Pichler, & Shafiq, 2021). Focusing on improving the STEM career ecosystem's resilience for underrepresented groups will improve the global STEM talent pool, resulting in a stronger STEM workforce and positive outcomes for organizations.

Limitations and conclusion

We introduced the metaphor of the STEM career ecosystem and used it to develop theory, but an overreliance on a single metaphor could limit thinking (Inkson, 2004). Morgan (1986) and Inkson (2004) advocate the simultaneous use of multiple metaphors to help reveal true understanding about a phenomenon. Future work could integrate the STEM career ecosystem metaphor with other existing STEM career metaphors to gain further insight into what may help make the ecosystem more resilient for members of all social identity groups.

We focused on societal, organization, and occupational cultures as major contextual influences informing our development of a model. Other contextual influences, however, are undoubtably contributors as well. Socioeconomic status and access to resources, such as education, networking, and vocational experiences are important systemic issues influencing individual STEM career decision making and behavior that should be explored in future research. Additionally, we used House et al.'s (2004) cultural dimension of gender egalitarianism to develop our theory. While gender egalitarianism as a cultural dimension is a straightforward representation of the extent to which cultures emphasize parity in gender roles, there is currently no standard measurement of the extent to which racial and ethnic minoritized groups are devalued in societal culture. Future research could develop a more direct way to examine attitudes toward race and ethnicity at the societal level. We infer that these cultural influences likely also exist within STEM organizations and occupations, reproducing systems that perpetuate inequities over time based on race and/or ethnicity.

Last, this research focused on contextual issues that have a disparate impact on women and racial and ethnic minoritized groups in STEM fields. We therefore did not consider individual-level variables that might serve as mitigating variables. For example, we did not consider whether career resilience (i.e., greater individual-level ability to navigate career setbacks and difficulties; London, 1983; Mishra & McDonald, 2017; Waterman, Waterman, & Collard, 1994) could help individuals navigate STEM career ecosystems that are fragile. Future research could examine whether career resilience interacts with STEM career ecosystem resilience in affecting individual career decision-making and behavior in STEM. The relationship between individual-level implicit theories of STEM and career resilience within STEM could also be examined in future research.

Despite these limitations, the career ecosystem metaphor provides a robust representation of contextual forces at the societal, organizational, and occupational levels that exert influence on individual STEM career decision-making and behavior. Additionally, the STEM context illustrates how career ecosystem resilience varies for different groups of actors based on social identity, creating a differentiated career ecosystem. The systemic problems of low representation and higher rates of occupational turnover for women and racial and ethnic minoritized groups are not unique to STEM fields; these problems are widespread across many types of careers. The career ecosystem metaphor—and associated testable models—present a promising framework from which to consider developing systemic solutions to strengthen the ecosystem and reduce the differentiation for members of different social identity groups.

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Figure 1.

The impact of culture on the STEM career ecosystem