# ISEE's Equity & Inclusion Theme

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*We acknowledge the work of many past PDP collaborators.*

## Context: Demographics of STEM in American Higher Education

In this brief overview we draw together data available from other sources into one high-level portrait of some basic demographics in STEM in American higher education. In a speech in 2003, Shirley Tilghman (then president of Princeton University) laid out a set of "compelling arguments why we should care about diversity in science." The final (and simplest) of these arguments was

> "…it is simply unjust for a profession to organize itself, intentionally or unintentionally, in such a way as to exclude a significant proportion of the population. This is an argument based on fairness and justice."[1]

This social justice argument is compelling only after one understands the facts of the proportions and populations that are included and not included in science and engineering. We will review the bases for the claims that disproportionally high rates of attrition out of STEM occur for some groups. In particular, this attrition occurs at every education and career level, including college settings where those who work with undergraduates (such as on inquiry activities and mentored projects) can have a significant impact.

It is common to begin by defining some terms: Women (of any race/ethnicity) and some minorities (of any gender) are not represented in STEM fields in proportions that match their fractions in the US population. These groups are therefore called "underrepresented." Not every minority group is underrepresented in US STEM: the Federal guidelines define underrepresented minority groups as Blacks, Latinas/os, Native Americans, Native Hawaiians, and Pacific Islanders. Conventional abbreviations include URM for "underrepresented minority" and UREP for underrepresented (including non-minority women). To be in the "double-bind"[2] as both a woman and a member of a minority group is a simple example of intersectionality.

### Considering Only a Limited Set of Demographic Factors

Race, ethnicity, and gender are obviously not the only forms of diversity, yet in this overview we focus only on those factors. There are many others (for example: disability status, sexual orientation) that are worth a broader discussion, but it is useful to have a limited subset of issues to begin discussion around. Focusing on race and ethnicity inevitably brings up concerns that class or socioeconomic status is being ignored. Of course both class and race/ethnicity matter. While datasets are not as extensive in higher education, in the K–12 arena achievement gaps are found between racial/ethnic groups and between economic classes. When either factor is held constant (race or class), gaps are strong functions of the other, independent factor.[3] As income and wealth disparities have widened, the corresponding achievement gaps have widened as well.[4] Race privilege is only one kind of privilege, and class privilege absolutely exists and intersects with other variables. The focus here on race, ethnicity, and gender is not meant to discount these other important considerations. However, Americans tend to prefer to "change the subject" away from race and toward class. Sometimes it is worthwhile to force ourselves to have the uncomfortable conversations. Inequities around race, ethnicity, and gender do exist, and those issues can be lost by attributing more to socioeconomics than the evidence supports. As we will present later in this document, the Focus Areas of ISEE's Equity & Inclusion Theme connect to issues of gender, race, and ethnicity, but do not exclude or preclude connections and intersections with other factors.

## Participation and Attrition in STEM

Figure 1 shows the relative proportions of underrepresented minorities in the college-age population, in college, receiving STEM bachelor's degrees, and receiving STEM doctoral degrees. All data are from a single 2011 National Academies report.[5] Note that all bars are restricted to US citizens only; this is important at the doctoral level where many STEM degree recipients are temporary residents. Of course, at each level of education, there are fewer students, but these bars show proportions, so they always total to 100%.

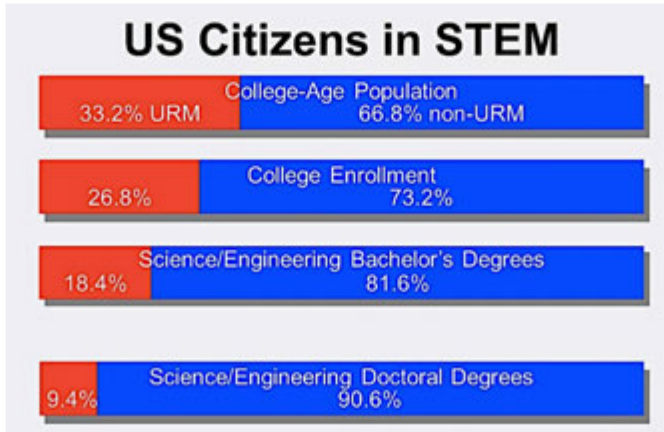


*Figure 1: The underrepresented minority share of the college-age population, college students, those who earn STEM bachelor's degrees, and those who earn STEM doctoral degrees. Data are restricted to US citizens only. Graphic made from data in [5].*

Members of the higher education community may point to the loss of minorities between the college-age population and college enrollment as outside of their control. But the drops in URM fraction after that point are comparable in scale (or worse) and illustrate the differential attrition that is entirely within the sphere of higher education's influence.

Tilghman's first argument for diversity in science was

> "…if we are not tapping into the entire talent pool that is available to make a contribution to science, the enterprise will by definition be under-performing its potential."[1]

To interpret the deficit of underrepresented minority participation as attrition, we turn to the demographics of that talent pool. In the past, underrepresented minorities did not pursue STEM in proportion to White and Asian students. However, now equal proportions of all groups set out to pursue STEM in college. Figure 2 shows the trend in who aspires to STEM majors.[6] The key feature is that

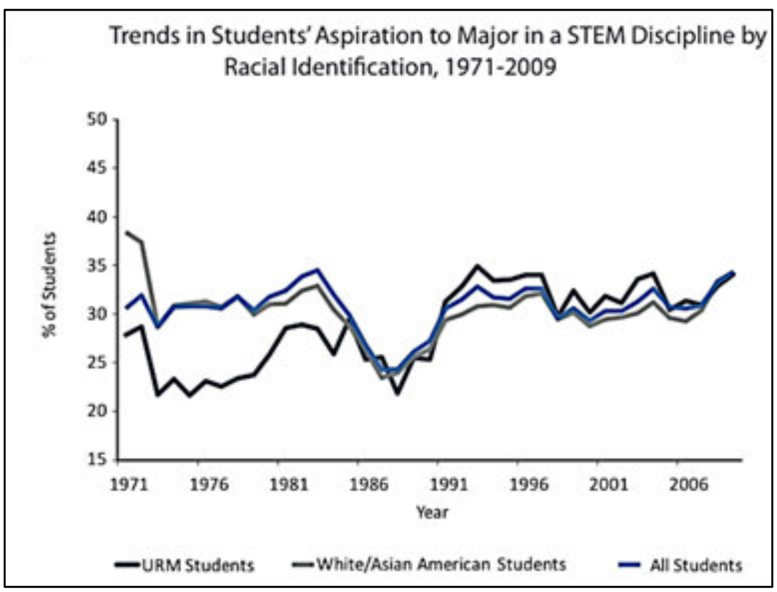


*Figure 2: Percentage of all students, underrepresented minority students, and White/Asian American students who aspire to a STEM discipline, taken directly from a UCLA HERI report.[6]*

 

~35% of all college students aspire to a STEM degree, and that proportion is essentially the same for any majority/minority subgroup.

If roughly equal proportions of students from all groups set out to pursue STEM in college, yet the outcomes do not maintain those equal proportions, then something happens in college. There is significant attrition for *all* students (regardless of background) in college. This attrition is more pronounced in STEM disciplines as compared to non-STEM disciplines—all students (regardless of background) who begin in a STEM discipline are significantly less likely to complete their degrees compared to students who begin pursuing other disciplines.[6] It is *in addition* that attrition disproportionally—more greatly—affects Blacks, Latinas/os, Native Americans, and other underrepresented minorities.

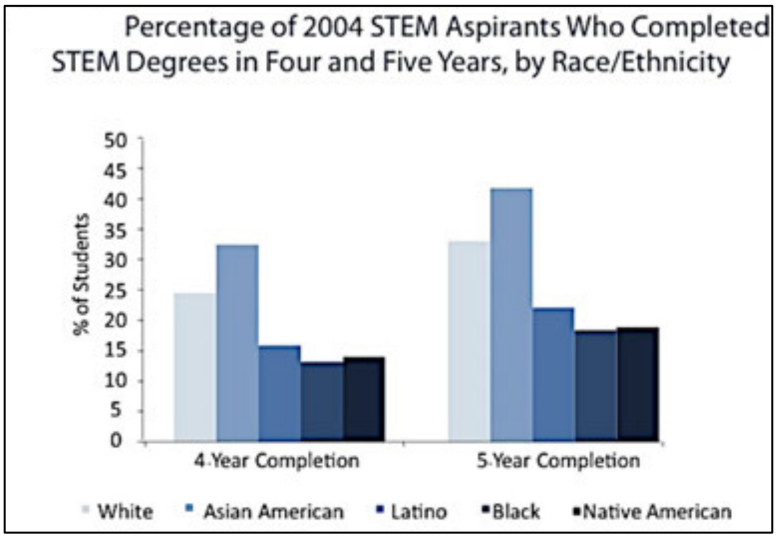


*Figure 3: Percentage of students who aspired to STEM degrees and completed STEM degrees, broken down by race/ethnicity, taken directly from the same UCLA HERI report.[6]*

Figure 3 shows the 4- and 5-year degree completion rates for only those students that aspired to STEM degrees. Since this graph focuses only on the ~35% of college students who aspire to science, if they were all successful in completing science degrees then the bars would show 100%. It is apparent from the figure that all groups experience significant attrition in STEM, and that underrepresented minorities experience differentially more attrition compared to Whites and Asians.

Many who worry about the US's scientifically- and technologically-literate workforce advocate recruiting more interest in STEM (usually by engaging and motivating young people). However, it is worth considering the fact that anyone who works with undergraduates is interacting with a large pool of students who are *already* motivated and interested in STEM, and these students are leaving *in college*. Making merely incremental improvements in STEM persistence and retention in college is a recommended, cost-effective strategy for meeting future workforce needs.[7]

Of course, some attrition results from students who perform very poorly in their STEM coursework. But many students leave STEM despite the fact that they are performing well in school. Above a cutoff of very poor grades, attrition does not correlate with performance; students who switch out of STEM and students who persist in STEM do not differ in competence.[8,9] ISEE's own data on ~200 Akamai interns indicate that their persistence in STEM years after their internship is not correlated with their GPA upon program entry. In other words, those who ultimately left STEM were just as likely to have had higher GPAs as lower ones. Assuming that attrition is entirely due to preparation and performance draws attention away from the concerning numbers of students who are doing well but leave STEM anyway. This attrition happens in college, where PDP participants and Akamai mentors can have a direct impact.

 

The patterns for women compared to men are not quite the same as for underrepresented minorities compared to Whites and Asians. At the college level, women do not set out to pursue STEM in the same proportions as men. In other words, the ~35% rate of STEM interest is not equally 35% of all men and 35% of all women. The population of college STEM degree aspirants includes proportionally more men, despite the facts that women take more science courses in high school, have better grades in high school science, and are the majority of college students. Figure 4 illustrates this, and shows apparently less attrition of women during college (although this depends on the particular discipline within STEM, which cannot be seen in these data). There may be more of a potential role for earlier interventions to increase young women's interest in STEM fields.[10]

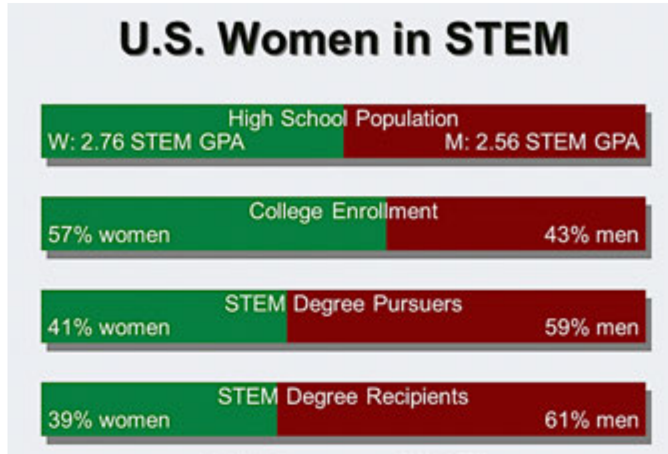


*Figure 4: Proportions of men and women in the high school population (with their STEM achievement levels), enrolled in college, pursuing STEM, and receiving STEM bachelor's degrees. Graphic made from data in [10].*

**Participation in Disciplines within STEM**

Tilghman's second argument for caring about diversity in science is that

> "…science will look increasingly anachronistic if women and minorities are not participants in the enterprise. As other professions move successfully toward a goal of inclusiveness, science will appear increasingly backward-looking, and will be less attractive to talented students of all types."[1]

Tilghman's original argument was about science as opposed to other professions. Figure 5 shows the URM share of degrees at different education levels and for different disciplines, from the last year this useful plot was updated.[11] For visual reference, the ~31.5% URM share of the US population[12] has been overplotted.

Engineering, mathematics, computer science, and the natural sciences have more minority underrepresentation than the social sciences and the non-sciences. According to Tilghman's reasoning, the social sciences and the non-sciences may out-compete STEM in attracting talent from all groups.

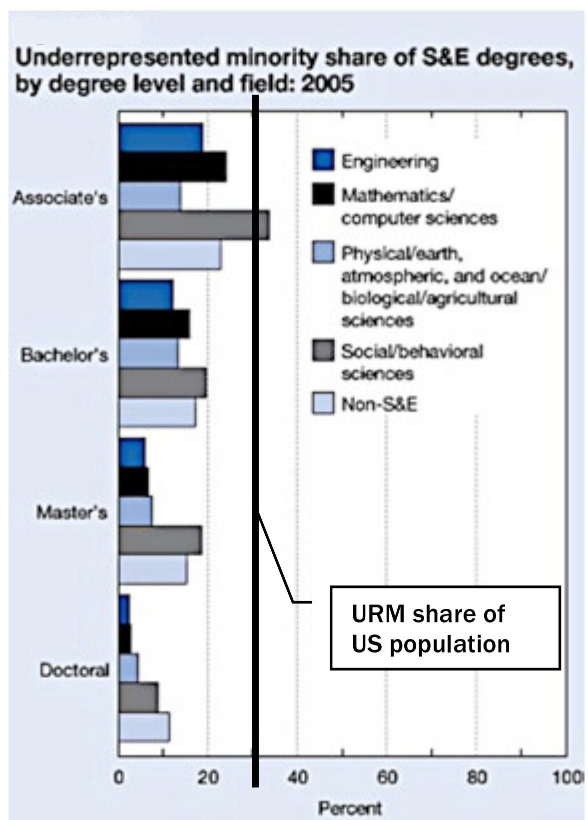


*Figure 5: The underrepresented minority share of associate's, bachelor's, master's, and doctoral degrees in various disciplines, taken directly from the Science & Engineering Indicators,[11] with the URM share of the US population[12] overplotted.*

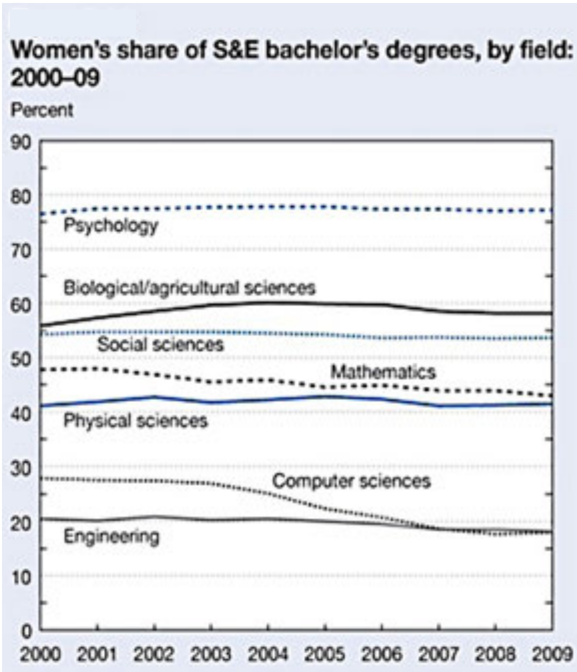


*Figure 6: Women's share of STEM bachelor degrees, broken down by discipline, taken directly from the Science & Engineering Indicators.*[13]

At a finer level of detail, disciplines within STEM compete with one another for talent. Figure 6 illustrates those details, but now with a focus on degrees earned by women rather than underrepresented minorities.[13] Different disciplines within STEM differ widely in successfully advancing women, and some disciplines are even losing ground.

There is a similar pattern of wide difference between the disciplines at the doctoral level. In 2010, women received ~23% of engineering PhDs, ~25% of math and computer science PhDs, ~32% of physical science PhDs, and ~58% of life science PhDs.[14]

It is not just that STEM suffers significant attrition at the undergraduate level; there are apparently also discipline-specific effects: "…undergraduate attrition out of agricultural/biological sciences, mathematics/ physical/computer sciences, and engineering is greater than transfers into those fields, but transfers into social/behavioral sciences are greater than attrition."[13*]

An important detail of Tilghman's reasoning here is that when a field begins to "look increasingly anachronistic if women and minorities are not participants," the field becomes less attractive to *all* talented students, not just students in the underrepresented groups.[1]

## Demographics Summary

STEM in the US does not reflect the demographics of the nation's population or of the students who aspire to STEM. Women, Blacks, Latinos/as, Native Americans, and Native Hawaiians and Pacific Islanders are underrepresented in STEM, but to varying degrees at different educational levels and in different disciplines. A key leverage point is the undergraduate level, where PDP participants and Akamai mentors working with ISEE can have a large impact on the persistence of students from any and all backgrounds.

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[*] This can lead to the claim that STEM majors are actually *more*, not less, persistent, depending on which exact disciplines "count" in one's definition of STEM. The UCLA HERI report[6] uses a definition of STEM fairly well aligned with ISEE: the biological, environmental, physical, mathematical, computer, and health sciences, and engineering. The NSF's publications,[11,13] on the other hand, sometimes include the social and behavioral sciences that attract and retain more students.

 

## The Equity & Inclusion Theme within ISEE and the PDP

ISEE recognizes that many social groups are not well represented in STEM, but we often focus on the starting point of women (of any race) and underrepresented minorities (of any gender). In addition, although there are many contexts in which issues of inclusion in STEM come up, ISEE often focuses on undergraduate learning experiences. PDP participants primarily work toward designing and facilitating undergraduate laboratory activities or other inquiry experiences; Akamai mentors and instructors build undergraduate internship projects and other activities.

We recognize that recruitment is extremely valuable for bringing more students into the STEM "pipeline," but it is easy to shift focus away from the students who are already in the STEM pipeline but are not being retained, as illustrated in the preceding demographics overview.

Turning away from recruitment and more toward the heart of STEM learning environments, a growing body of evidence indicates that, by thoughtfully designing inquiry activities and inquiry-like projects (such as internship projects), a positive impact can be made on students directly. Learning environments (including the curricula, specific activities, interactions with peers, instructors, mentors, and the overall classroom and/or workplace community) can be created to be equitable and inclusive of a diversity of learners.

Pursuing these goals brings up the tensions between viewing a learner as an individual (with multiple identities, motivations, beliefs, goals, etc.) and viewing a learner as a member of groups (with demographics, social and cultural practices, historical relationships to STEM, access to power and privilege, etc.). A single inquiry activity or internship project can begin to contribute to inclusion, or can build on contributions previously made. Many such excellent experiences can contribute significantly to learners' senses of identification with STEM, making them more likely to persist.

### Organizing the Issues into Focus Areas

While we at ISEE are well informed, we are not experts in all of the many different literatures from many different disciplines around diversity, equity, privilege, and inclusion. What follows is not a review that organizes those literatures into themes that experts in those fields would necessarily recognize. Instead, we have noticed ways in which certain themes from that body of expertise seem to resonate with or play out within contexts we are familiar with—primarily inquiry activities and mentored undergraduate internship projects.

Our contribution is a set of four focus areas, with a practice-oriented perspective, that highlight the ways that inquiry is connected to a

**Equity & Inclusion Focus Areas**

1. **Multiple ways to productively participate**
More learners are included, and more of their skills are developed, when they are provided with multiple ways to engage, learn, communicate, and succeed.
2. **Learners' goals, interests, and values**
Inclusivity is supported by leveraging learners' goals, interests, values, and sources of motivation through activities that are relevant, meaningful and challenging.
3. **Beliefs and biases about learning, achievement, and teaching**
Learners and educators develop beliefs about learning, achievement, competency, and intelligence that affect performance and success in STEM.
4. **Developing an identity as a person in STEM**
STEM learning experiences are part of the process of learners negotiating their individual identities and their sense of being a person in STEM, which has cultural norms and values of its own.

diverse body of literature on equity and inclusion. These focus areas provide a structure for insight into why inquiry pedagogy holds such promise for reducing disparities. The structure also allows us to examine how our parallel experiences in mentoring projects can both benefit from and contribute to what is known about equity and inclusion.

We offer the focus areas of the E&I theme as lenses, with which instructors and mentors can view the design and facilitation of inquiry activities and projects, and aim to strengthen equity and inclusion. As with ISEE's other themes, this theme is applicable in other STEM contexts.

In the next sections, we describe the Equity & Inclusion Focus Areas in more detail and give some concrete examples of integrating them into design and facilitation.

### 1. Multiple ways to productively participate

People have different prior experiences and communicate their knowledge in different ways. Their backgrounds can limit their access and opportunity to participate in science and engineering, but can also be sources of new ideas and approaches. In addition, the learning environment, including the specific activities themselves and the interactions between instructors, mentors and learners, can either constrain or promote learners' participation in important STEM practices.[15] Learners' backgrounds shape how they communicate and demonstrate success, so that success can look and sound very different for different learners. A complex confluence of factors, related to the individuals involved, their past participation in various communities, and how they are engaged in the activity, influence the outcomes. Learning environments that provide multiple ways to learn, communicate, and succeed are more likely to engage a broader range of learners.[16,17]

It is not that learners need multiple ways to participate because they have a diversity of fixed "learning styles." In fact, the existence of fixed learning styles is not supported by the evidence.[18] Instead, instructors and mentors can give learners practice and support for learning in new ways, expanding their repertoire, rather than treating their preferences as static traits.[19] Articulating clear learning goals or expected project outcomes, and providing multiple avenues for learners to achieve goals and demonstrate success, supports more learners succeeding. Providing multiple ways for learners to express their knowledge, or demonstrate skills, helps both instructors/mentors and learners assess learners' understandings. Providing challenging work, along with supportive structures for learners to succeed in that work, makes their participation productive and conveys high expectations for all learners.

When learners can productively participate in collaborative participant structures, the experience mirrors productive collaborations in STEM. These collaborations should be inclusive both because social interaction plays a fundamental role in learning,[20] and because cooperative learning can support relations between people from different backgrounds.[21] Cooperative learning structures also provide vicarious learning experiences (watching others model something before trying it), a way of building self-efficacy, and may be more important for some learners than others.[22]

Simple examples of how this focus area could be applied to activity design, project design, facilitation, and mentoring:

- Inquiry activity is designed with a mix of participant structures, e.g., learners spend some time working independently, some time in groups, and some time in lecture.

 

- Instructors build into activities opportunities for learners to express their understandings in several ways, e.g., by talking about them, drawing figures, referring to graphs, and writing. Productive contributions of any form are valued and recognized.
- Activity is designed so that learners spend a significant amount of time working in small groups of 2–3 learners, so that each learner can make a significant contribution to the group's progress.
- Social dynamics in an activity are managed or designed so that no one learner's participation interferes completely with another's.
- Instructors make moves to get all learners talking and engaging with materials in meaningful ways, managing the social dynamics and the physical arrangement of materials.
- A project provides opportunities for the learner to excel at the detailed task itself, and at project planning and reporting to others on work progress.
- Mentors create opportunities for the learner to work on parts of a project with different colleagues, who may work or communicate in different ways.

**2. Learners' goals, interests, and values**

Learners come into science and engineering lab experiences with different goals, interests, and values that are formed in part from their social, cultural and educational background, and are shaped by their future plans.[23] They have different views of intelligence that can affect their goals and their motivation. In other words, their values and motivation are shaped not only by their own educational and career plans, but in part by their past experiences and backgrounds.[24] Differences in performance between different groups decrease when learners have an opportunity to reflect on and affirm their values.[25] Effective learning environments can be designed to anticipate and leverage learners' goals, interests, values, and sources of motivation through activities that are relevant, meaningful, and challenging. Instructors and mentors can find out about their learners' backgrounds, draw from them as resources, and help learners find connections and relevance to their own lives. Learners' agency—the capacity of individuals to make choices and act on their own behalf—is affected by their background and the learning experiences they are engaged in. Shifting the social constraints so that previously less-privileged learners gain power through their mastery of STEM develops their agency.[26] The practices that instructors and mentors use to engage learners are as important as the curriculum itself.[27]

Simple examples of how this focus area could be applied to activity design, project design, facilitation, and mentoring:

- Inquiry activity and project goals connect the content, practices, and attitudes required for success to learners' goals, interests, values, and potential motivations.
- Activity is designed so that learners can pursue the questions and/or investigation paths that interest them most, and lead to the intended learner outcomes.
- Facilitation plan is flexible enough to support learners who show interest in unanticipated questions and/or investigation paths that are relevant to the activity content and process goals.
- Project has multiple possible solution pathways or components of the solution, which can lead to learner "ownership" over some particular part.
- Mentors take opportunities to learn about learners' backgrounds and interests, and consider ways that the project could build on them.

 

### 3. Beliefs and biases about learning, achievement, and teaching

People hold different beliefs about learning, intelligence, achievement, competency, and teaching that bring everyone—learners, instructors, and mentors—into a lab with assumptions and expectations about themselves and others.[28] Stereotype threat, triggered by the mere existence (not necessarily endorsement) of negative stereotypes and by seemingly innocuous aspects of the environment, can intensify learners' assumptions about themselves and negatively impact learners' performances.[29,30,31,32] If instructors and mentors do not convey positive and equitable views of learning, they can create environments that limit access, opportunity, and agency, particularly for learners of non-dominant backgrounds. Projecting high expectations along with support for all learners' success provides opportunities for more learners to succeed.[33] One way to do this is to approach intelligence as a changeable, rather than fixed, trait, expressing all learners' ability to improve and build on their understandings.[34,35] A "growth mindset" appears to buffer learners from negative stereotypes about their group(s), which can both improve their performance[36] and their "sense of belonging" in the discipline.[37] (An entire chapter devoted to mindset is available in [10].) Learners' beliefs about their own self-efficacy in STEM affect their persistence, and their self-efficacy is developed from different sources for people from different groups (e.g., genders).[22]

Unconscious biases can affect teaching and learning,[38] as well as views of competency that impact hiring practices and other important aspects of career advancement.[39] Views held by instructors/mentors and learners can be difficult to identify and change, but a practice of ongoing reflection and self-monitoring about one's assumptions can in time bring beliefs to the surface. With personal views about teaching and learning more clearly expressed, perspectives that may be translated into performance-limiting practices can be re-evaluated, and ultimately practices can change.

Simple examples of how this focus area could be applied to activity design, project design, facilitation, and mentoring:

- Inquiry activity is designed with multiple possible starting points, acknowledging learners' different prior knowledge and experiences, and reinforcing an expectation that they can make meaningful knowledge gains no matter what their starting point is.
- Learning goals are challenging and convey an assumption that learners are ready for challenge (but, simultaneously, the activity is designed with adequate supports so learners can succeed).
- During learner investigations/projects, instructors/mentors give guidance when requested or needed but ultimately convey the expectation that learners will be able to "figure it out." Instructors/mentors think ahead about a few key points in the activity/project where their learners' backgrounds and experience levels may come up, and then plan their words carefully to avoid comments that imply static traits, or the message that "you've either got it or you don't."
- Mentors design a real project with real value, and convey how the project contributes something important within the organization.
- Practice and improvement are recognized and valued.
- Opportunities to practice and get feedback on challenging aspects of a project are structured into the learner's overall experience.

 

- Unnecessary events that might trigger stereotype threat (e.g., inappropriately highlighting gender or race, describing abilities or achievements in unintentionally “fixed” terms, etc.) are rooted out and avoided.

**4. Developing an identity as a person in STEM**

We start with a quote from Chapter 7 of [23] (emphasis added): “Researchers studying motivation have developed a dizzying array of theoretical frameworks, making it challenging to develop a coherent picture of motivation, attitudes, and *identity* and the factors that shape them.” In the framework presented there, “identity” is operationalized as a learner’s sense of belonging and sense that STEM is an important part of who they are. Others have broken out a sense of belonging as a separate (but important) concern, leaving “identity” as the extent to which the learner views him/herself as a scientist/engineer or a “person in STEM.” [40] A framework for STEM identity has emerged that emphasizes competence, performance, and recognition.[41] In this framework, competence is the learner’s knowledge of STEM content and practices, and the learner’s beliefs about that knowledge (self-efficacy). Performance is the social demonstration of competence in classroom, laboratory, and professional settings within the authentic culture of STEM. The third component is explicit recognition (both from others and from the learner as self) of competence and performance within STEM culturally appropriate ways. For example, rather than congratulations from non-STEM friends and family, recognition might entail informal references to the learner’s contributions among students, instructors, or colleagues, or more formal authorship on a publication. Others have pointed out that it is not only the learners’ self-views of who they are, but also who they want to become and what they want to become part of that is an important component of identity development.[42,43] As part of the “dizzying array” of constructs in this area, self-efficacy and agency—beliefs in one’s ability to achieve competence, master performances, make choices, and act on one’s own behalf—are inextricably linked to identity.[22,26]

Learners’ conscious or unconscious beliefs and preferences about how others view them can cause them to “disidentify” when under stereotype threat.[44] The interplay between learners’ existing and developing identities, the broader sociocultural world, and the world of STEM (with its own cultural norms, practices, and values) has an enormous effect on their participation.[45,41] STEM’s culture has been shaped by the backgrounds of those historically dominant in the field, and may therefore make STEM less attractive to people from non-dominant backgrounds, and even drive some learners out of STEM.[8,46] Attention to the interplay between learners’ cultural backgrounds and the culture of STEM can help educators create a more inclusive environment.

Providing role models that learners identify with specifically in demographic terms may help[47] or may not,[48] but effective mentoring can be done by people of all backgrounds. Providing learners with experiences focused on the kinds of things that inquiry emphasizes—conceptual understanding, engaging in STEM practices—has been linked to developing a positive STEM identity and career choice.[43] Being explicit about the norms and practices of STEM while valuing learners’ own cultural norms and practices can help learners of diverse backgrounds successfully navigate between STEM and their everyday lives.[23] Failure to authentically recognize the accomplishments of learners from diverse backgrounds as they gain knowledge and skills in STEM detracts from their STEM identity development and ultimately contributes to attrition.[41]

 

Simple examples of how this focus area could be applied to activity design, project design, facilitation, and mentoring:

- Inquiry activity goals include learning STEM norms and practices, such as explaining or even defending one's results by referring to relevant data and scientific principles, and the activity makes the norms explicit to all learners.
- Activity can be designed to include segments in which learners describe their work informally, as they might to family and friends, and then describe their work formally, as they would at a conference. Learners reflect on and identify the differences between presentation styles.
- Instructor can wrap up activity by reviewing learning goals, referencing each learner's progress to reinforce their sense of accomplishment and belonging in STEM.
- Activity or project design explicitly attends to learner's competence, performance, and recognition of them in authentic STEM contexts.
- Connections are made explicit between what learners experience in an activity and what happens in authentic STEM contexts (e.g., STEM practices, problems, unexpected outcomes, collaboration, uncertainty, etc.).
- Project includes not only opportunities for the learner to build skills with respect to the technical details, but also opportunities for recognition in appropriate STEM workplace venues (group meetings, presentations, etc.).
- Mentor periodically updates colleagues on the intern's progress and/or upcoming tasks, opening opportunities for the intern to informally share progress and be recognized for accomplishments.

## Some Fruitful Ideas Cross the Focus Areas

The four focus areas are not meant to imply that these are four distinct areas of equity and inclusion considerations. In fact, some of the richest and most fruitful insights involve more than one of our focus areas. A simple example is that giving learners challenging work to make sure their participation is productive (FA #1) also conveys growth-mindset beliefs (FA #3) and contributes to learners' competence and opportunities for performance (FA #4). Broadly, many constructs seem to detract from or contribute to a learner's sense of STEM identity (FA #4). For instance, while stereotype threat (FA #3) can severely impact a learner's senses of belonging and identity, a "growth mindset" (FA #3) can protect learners from the threat and encourage belonging, identity, and persistence.[37] Interest (FA #2) is a crucial component[43] of a learner's STEM identity, in addition to her/his competence, performance, and recognition.[41] Self-efficacy and agency—which relate to learners' self-beliefs (FA #3) and their goals (FA #2) are also hard to disentangle from identity.[22,26]

Most of these considerations are concerned with the *affective domain*—learners' noncognitive, emotional, attitudinal responses to the STEM learning environment. Since learners' affects can have such profound effects on their learning and persistence, thoughtful attention to the affective domain is needed while structuring projects and activities that support traditional concerns such as STEM concepts and practices.[40]

It is useful to think of the E&I Focus Areas as lenses for analysis rather than distinct groupings of constructs, because all the constructs are interrelated and interact.

 

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## References Cited


[1] Tilghman, S.M., 2003. "The 2003 Killam lecture: The challenges of educating the next generation of the professoriate." Presented at the University of British Columbia, http://www.princeton.edu/president/speeches/20031023/

[2] Malcom, S.M., Hall, P.Q., & Brown, J.W., 1976. "The double bind: The price of being a minority woman in science." Washington DC: American Association for the Advancement of Science.

[3] National Center for Educational Statistics, US Dept. of Education, "National assessment of educational progress—the nation's report card," http://nces.ed.gov/nationsreportcard/

[4] Reardon, S.F., 2011. "The widening academic achievement gap between the rich and the poor: New evidence and possible explanations," in *Whither Opportunity? Rising Inequality and the Uncertain Life Chances of Low-Income Children*, R. Murnane & G. Duncan, eds. New York: Russell Sage Foundation, http://cepa.stanford.edu/content/widening-academic-achievement-gap-between-rich-and-poor-new-evidence-and-possible-explanations

[5] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011. *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, Committee on Science, Engineering, and Public Policy. Washington DC: National Academies Press, http://www.nap.edu/catalog.php?record_id=12984

[6] Hurtado, S., Eagan, K., & Chang, M., 2010. "Degrees of success: Bachelor's degree completion rates among initial STEM majors." Higher Education Research Institute, UCLA, http://heri.ucla.edu/nih/downloads/2010 - Hurtado, Eagan, Chang - Degrees of Success.pdf

[7] President's Council of Advisors on Science and Technology, Feb. 2012. "Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics," http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf from http://www.whitehouse.gov/administration/eop/ostp/pcast/docsreports

[8] Seymour, E., and Hewitt, N.M., 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder CO: Westview Press.

[9] Tobias, S., 1990. "They're not dumb, they're different: A new 'tier of talent' for science." *Change* **22**, 11–30


 

[10] Hill, C., Corbett, C., & St. Rose, A., 2010. *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. Washington DC: AAUW, http://www.aauw.org/learn/research/whysofew.cfm

[11] National Science Board, 2008. *Science and Engineering Indicators 2008*. Arlington, VA: National Science Foundation, http://www.nsf.gov/statistics/seind08/

[12] Humes, K.R., Jones, N.A., & Ramirez, R.R., 2011. "Overview of race and Hispanic origin: 2010." 2010 Census Briefs, US Census Bureau, http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf

[13] National Science Board, 2012. *Science and Engineering Indicators 2012*. Arlington, VA: National Science Foundation, http://www.nsf.gov/statistics/seind12/

[14] National Science Foundation. WebCASPAR: Integrated Science and Engineering Resources Data System, https://webcaspar.nsf.gov/ (In this case Integrated Postsecondary Education Data System (IPEDS) completion data were selected from the National Center for Education Statistics (NCES). Several informative data sources can be combined at the WebCASPAR site.)

[15] Ball, T. & Hunter, L., 2013. "Supporting access to science and engineering through scientific argumentation," in *Pedagogy in Higher Education: A Cultural Historical Approach*; editors: G. Wells and A. Edwards. New York, NY: Cambridge University Press.

[16] NRC 1999, *How People Learn: Brain, Mind, Experience, and School*. National Research Council: Committee on Developments in the Science of Learning; editors J.D. Bransford, A.L. Brown, and R.R. Cocking. Washington DC: National Academies Press, http://www.nap.edu/html/howpeople1/

[17] NRC 2005, *How Students Learn: History, Mathematics, and Science in the Classroom*. National Research Council: Committee on How People Learn. Washington DC: National Academies Press, http://www.nap.edu/catalog/10126.html

[18] Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R., 2008. "Learning styles: Concepts and evidence." *Psychological Science in the Public Interest*, **9** (3) 105–119, http://www.psychologicalscience.org/journals/pspi/PSPI_9_3.pdf

[19] Gutiérrez, K.D. & Rogoff, B., 2003. "Cultural ways of learning: Individual traits or repertoires of practice." *Educational Researcher* **22** (5), 19–25, http://people.ucsc.edu/~brogoff/Scanned-articles/scanned%2012-2008/Cultural%20ways%20of%20learning.pdf

[20] Vygotsky, L.S., 1978. *Mind in Society: The Development of Higher Psychological Processes.* Cambridge: Harvard University Press.

[21] Slavin, R.E., & Cooper, R. (1999). "Improving intergroup relations: Lessons learned from cooperative learning programs." *Journal of Social Issues*, **55** (4), 647–664, http://onlinelibrary.wiley.com/doi/10.1111/0022-4537.00140/abstract

[22] Sawtelle, V., Brewe, E., & Kramer, L.H., 2012. "Exploring the relationship between self-efficacy and retention in introductory physics." *Journal of Research in Science Teaching*, **49** (9) 1096–1121 http://onlinelibrary.wiley.com/doi/10.1002/tea.21050/abstract

 

[23] NRC 2007. *Taking Science to School: Learning and Teaching Science in Grades K–8*. National Research Council: Committee on Science Learning, Kindergarten through Eighth Grade; editors R.A. Duschl and H.A. Schweingruber. Washington DC: National Academies Press, http://www.nap.edu/catalog.php?record_id=11625

[24] Osborne, J.F., Simon, S., & Collins, S., 2003. "Attitudes toward science: A review of the literature and its implications." *International Journal of Science Education* **25** (9), 1049–1079. http://www.tandfonline.com/doi/abs/10.1080/0950069032000032199#.UwpGPONdV8E

[25] Miyake, A., Kost-Smith, L.E., Finkelstein, N.D., Pollock, S.J., Cohen, G.L., & Ito, T.A., 2010. "Reducing the achievement gap in college science: A classroom study of values affirmation." *Science* **330**, 1234–1237

[26] Basu, S.J., & Barton, A.C., 2009. "Critical physics agency: Further unraveling the intersections of subject matter knowledge, learning, and taking action." *Cultural Studies of Science Education* **4** (2) 387–392. http://link.springer.com/article/10.1007/s11422-008-9155-4

[27] Boaler, J., 2002. "Learning from teaching: Exploring the relationship between reform curriculum and equity." *Journal of Research in Mathematics Education* **33** (4) 239–258, http://www.jstor.org/stable/749740

[28] Bianchini, J.A., & Solomon, E.M., 2002. "Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers." *Journal of Research in Science Teaching* **40** (1) 53–76, http://onlinelibrary.wiley.com/doi/10.1002/tea.10060/abstract

[29] Steele, C. M., & Aronson, J., 1995. "Stereotype threat and the intellectual test performance of African-Americans." *Journal of Personality and Social Psychology* **69**, 797–811, http://psycnet.apa.org/journals/psp/69/5/797/

[30] Gonzales, P. M., Blanton, H., & Williams, K. J., 2002. "The effects of stereotype threat and double-minority status on the test performance of Latino women." *Personality and Social Psychology Bulletin* **28**, 659–670, http://psp.sagepub.com/content/28/5/659.short

[31] Schmader, T., Johns, M., & Forbes, C., 2008. "An Integrated Process Model of Stereotype Threat Effects on Performance." *Psychological Review* **115** (2), 336–356, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2570773/

[32] Stroessner, S., & Good, C., 2007–2014. Reducing stereotype threat, http://www.reducingstereotypethreat.org

[33] Cohen, G. L., Steele, C. M., & Ross, L. D. (1999). "The mentor's dilemma: Providing critical feedback across the racial divide." *Personality and Social Psychology Bulletin* **25**, 1302–1318, http://psp.sagepub.com/content/25/10/1302.short

[34] Aronson, J., Fried, C. B., & Good, C., 2002. "Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence." *Journal of Experimental Social Psychology* **38**, 113–125, http://www.sciencedirect.com/science/article/pii/S002210310191491X

[35] Dweck, C.S., 2006. *Mindset: The New Psychology of Success*. New York: Random House, http://mindsetonline.org

 

[36] Good, C., Aronson, J., & Inzlicht, M., 2003. "Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat." *Applied Developmental Psychology* **24**, 645–62, http://www.michaelinzlicht.com/research/research_articles/Good,%20Aronson,%20Inzlicht,%202003.pdf

[37] Good, C., Rattan, A., & Dweck, C.S., 2012. "Why do women opt out? Sense of belonging and women's representation in mathematics." *Journal of Personality and Social Psychology* **102** (4) 700–717, http://psycnet.apa.org/journals/psp/102/4/700/

[38] Lavy, V., & Sand, E., 2015. "On the origins of gender human capital gaps: Short and long term consequences of teachers' stereotypical biases." Working Paper #20909, *National Bureau of Economic Research, http://www.nber.org/papers/w20909*

[39] Moss-Racusin, C.A., Dovidio, J.F., Brescoll, V.L., Graham, M.J., & Handelsman, J., 2012. "Science faculty's subtle gender biases favor male students." *Proceedings of the National Academy of Sciences* **109** (41) 16474–16479, http://www.pnas.org/content/109/41/16474.full.pdf+html

[40] Trujillo, G., & Tanner, K.D., 2014. "Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity." *CBE—Life Sciences Education* **13** 6–15, http://www.lifescied.org/content/13/1/6.short

[41] 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, http://onlinelibrary.wiley.com/doi/10.1002/tea.20237/abstract

[42] Brickhouse, N.W., Lowery, P., & Schultz, K., 2000. "What kind of a girl does science? The construction of school science identities." *Journal of Research in Science Teaching* **37** (5) 441–458, http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1098-2736(200005)37:5%3C441::AID-TEA4%3E3.0.CO;2-3/abstract

[43] 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, http://onlinelibrary.wiley.com/doi/10.1002/tea.20363/abstract

[44] Osborne, J.W., 1995. "Academics, self-esteem, and race: A look at the underlying assumptions of the disidentification hypothesis." *Personality and Social Psychology Bulletin* **21** (5) 449–455, http://psp.sagepub.com/content/21/5/449.abstract

[45] Reveles, J.M., & Brown, B.A., 2008. "Contextual shifting: Teachers emphasizing students' academic identity to promote scientific literacy." *Science Education* **92** (6) 1015–1041, http://onlinelibrary.wiley.com/doi/10.1002/sce.20283/abstract

[46] Brickhouse, N.W., & Potter, J.T., 2001. "Young women's scientific identity formation in an urban context." *Journal of Research in Science Teaching* **38** (8) 965–980, http://onlinelibrary.wiley.com/doi/10.1002/tea.1041/abstract

[47] Marx, D. M., & Roman, J. S., 2002. "Female role models: Protecting women's math test performance." *Personality and Social Psychology Bulletin*, **28**, 1183–1193, http://psp.sagepub.com/content/28/9/1183.short

 

[48] Hazari, Z., Potvin, G., Lock, R.M., Lung, F., Sonnert, G., & Sadler, P.M., 2013. "Factors that affect the physical science career interest of female students: Testing five common hypotheses." *Physical Review Special Topics: Physics Education Research* **9** (2) 020115, http://journals.aps.org/prstper/pdf/10.1103/PhysRevSTPER.9.020115

 