Title

ISEE's Equity & Inclusion Theme

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DESCRIPTION

This paper was written and produced by the developers of the Professional Development Program (PDP) at the Institute for Scientist & Engineer Educators (ISEE) at University of California, Santa Cruz. The PDP was a flexible, multi-year program which trained participants to teach STEM effectively and inclusively at the post-secondary level. Participants were primarily graduate students and postdocs pursuing a broad range of science and engineering careers. Participants received training through two in-person multi-day workshops, worked on a team to collaboratively design an authentic, inclusive STEM learning experience (an "inquiry" lab), and then put their new teaching skills into practice in programs or courses, mostly at the college level. Throughout their experience, PDP participants used an array of online tools and received coaching and feedback from PDP instructors. The overall PDP experience was approximately 90 hours and was framed around three major themes: inquiry, assessment, and equity & inclusion. Leadership emerged as a fourth theme to support PDP teams, which were each led by a participant returning to the PDP for a second or third time, who gained training and a practical experience in team leadership. ISEE ran the PDP from 2001-2020, and there are more than 600 alumni.

CONTEXT FOR THIS PAPER WITHIN THE PDP

This paper outlines one of the PDP's three major themes, "equity & inclusion," and includes the four focus areas that participants use throughout their experience. The paper was read by participants prior to beginning their PDP experience; then framed discussions during workshops, participants' work as they designed learning experiences, feedback from PDP instructors, and participants' reflection on the PDP experience. The four focus areas are a narrow slice of the knowledge base on equity and inclusion, chosen to align with the career interests of PDP participants, and to support them in being able to incorporate something concrete into the teaching of a lab unit during their PDP experience. The focus areas have broader applicability, but it is important to keep in mind that ISEE's Equity & Inclusion Theme framed professional development, and because of this was kept focused on what an individual instructor could implement in a small piece of curriculum.

The PDP was a national program led by the UC Santa Cruz Institute for Scientist & Engineer Educators. The PDP was originally developed by the Center for Adaptive Optics with funding from the National Science Foundation (NSF) (PI: J. Nelson: AST#9876783), and was further developed with funding from the NSF (PI: L. Hunter: AST#0836053, DUE#0816754, DUE#1226140, AST#1347767, AST#1643390, AST#1743117) and University of California, Santa Cruz through funding to ISEE.

ISEE's Equity & Inclusion Theme

Scott Seagroves, Rafael Palomino, Nicholas McConnell, Anne Metevier, Austin Barnes, Tiffani Quan, and Lisa Hunter

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, Latinx, 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. Inequities around race, ethnicity, and gender do exist, and those issues can be lost by attributing more to socioeconomics than the evidence supports. Conversations that make members of dominant/privileged groups uncomfortable are imperative for advancing equity. 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%.

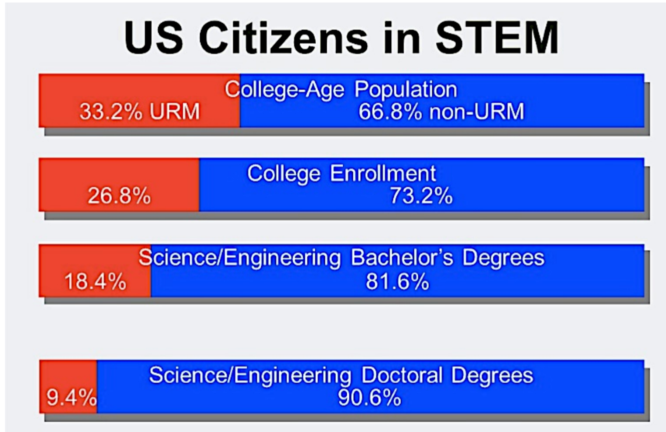

Figure 1: The underrepresented minority share of the college-age population, college students, those who earn STEM bachelor's degrees, and those who earn STEM doctoral degrees. Data are restricted to US citizens only. Graphic made from data in [5].

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, since 1985, equal proportions of all groups have set out to pursue STEM in college (Box 1).[6] As of 2009, ~35% of all college students aspired to a STEM degree, and that proportion is essentially the same for any majority/minority subgroup.

Box 1: Equal aspiration toward STEM degrees

According to a UCLA Higher Education Research Institute (HERI) report from 2010,[6] equal proportions of underrepresented minority students and White/Asian American students have aspired to major in a STEM discipline since 1985. As of 2009, roughly 35% of all college students aspired to a STEM degree, regardless of whether they belonged to a majority or minority subgroup.

[*] Unfortunately, "Asian" and "Asian-American" are incredibly broad demographic categories that fail to capture significant disparities in participation between various national and ethnic groups.

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 more prone to attrition from college compared to students who begin pursuing other disciplines.[6] It is *in addition* that attrition disproportionally—more greatly—affects Black, Latinx, Native American, and other underrepresented minority students.

Box 2: Differences in STEM degree completion rates

Approximately 33% and 42% of White and Asian American STEM majors, respectively, completed their bachelor's degree in STEM within five years of college entry. In contrast, five-year STEM completion rates for Latino, Black, and Native American students were 22.1%, 18.4%, and 18.8%, respectively.[6]

As highlighted in Box 2, the 4- and 5-year degree completion rates for only those students that aspired to STEM degrees differed depending for students of different majority and minority groups.[6] If all college students who aspired to a STEM major were successful in completing degrees in these fields, then the completion rate would be 100%. However, all groups experience significant attrition in STEM, with underrepresented minorities experiencing 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.

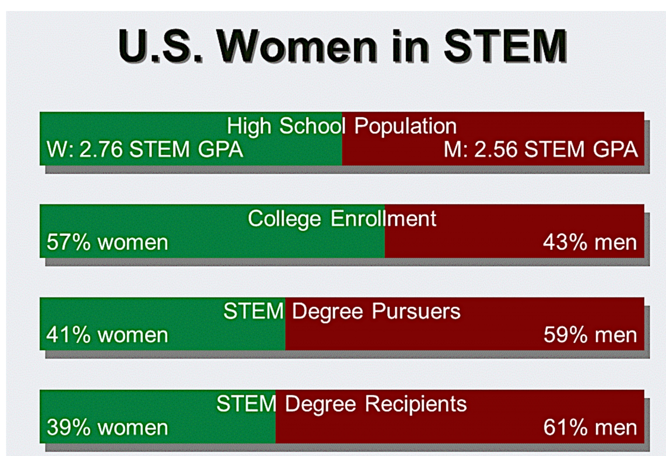

Figure 2: Proportions of men and women in the high school population (with their STEM achievement levels), enrolled in college, pursuing STEM, and receiving STEM bachelor's degrees. Graphic made from data in [10].

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 2 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]

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 3 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 reference, the URM share of the US population was ~31.5% as of 2012[12]. Engineering, mathematics, computer science, and the natural sciences have more minority underrepresentation than the social sciences and the non-sciences.

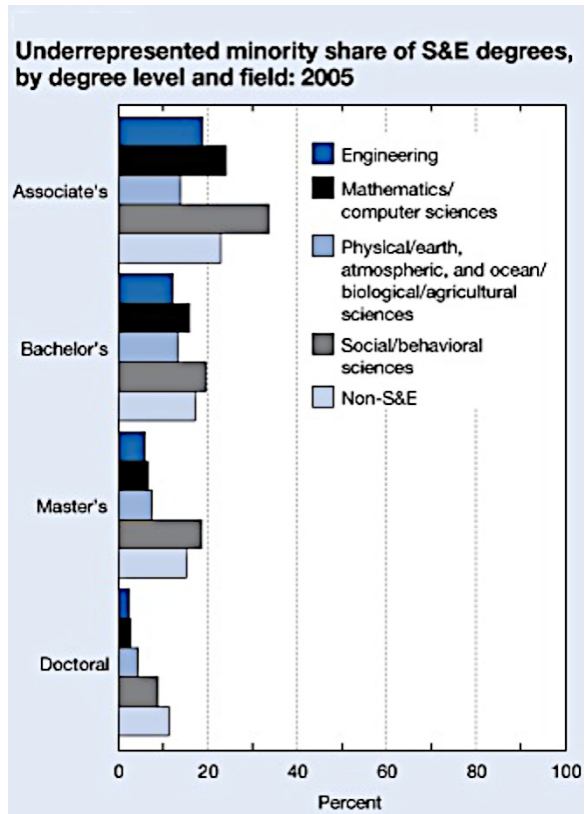

*Figure 3: The underrepresented minority share of associate's, bachelor's, master's, and doctoral degrees in various disciplines, taken directly from the Science & Engineering Indicators[11]. As of 2012, the URM share of the US population was 31.5%.**Error! Bookmark not defined.***

At a finer level of detail, different disciplines within STEM attract and retain different proportions of underrepresented students. Figure illustrates those details, but now with a focus on degrees earned by women rather than underrepresented minorities.[12] While Figure 4 illustrates a wide range of success in advancing women to bachelor's degrees (or failure – with some disciplines even losing ground over the decade illustrated), 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.[13]

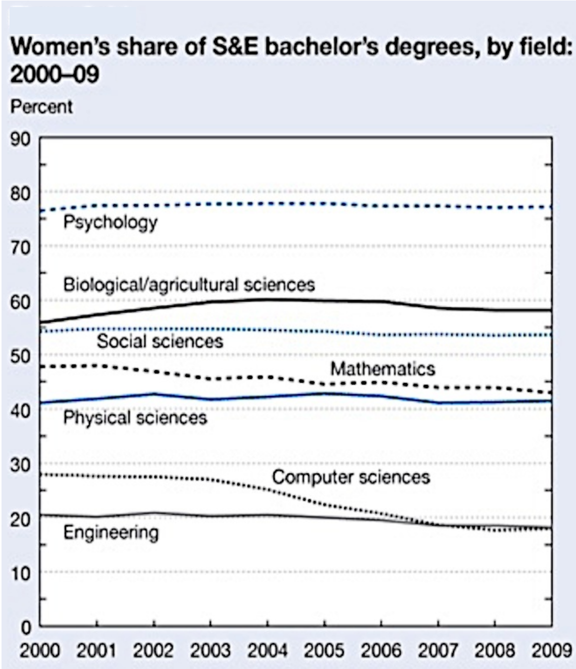

Figure 4: Women's share of STEM bachelor degrees, broken down by discipline, taken directly from the Science & Engineering Indicators.[12]

By Tilghman's reasoning, STEM disciplines are competing with one another and with non-STEM fields for talented new students, and diversity is an appealing trait to students from majority and minority groups alike. This argument alludes to but does not address head-on the severe challenges that an "anachronistic [,...] backward-looking" profession creates for individuals currently within the profession. Scientists and engineers who work or study as the only * (where * might be "woman faculty member," "African American," "transgender person," etc.) in their department or at a conference often must deflect stereotypes, serve as involuntary spokespeople for an entire demographic group, and navigate policies, norms, and physical spaces that were constructed without attention to their needs. Additionally, underrepresented individuals are pressed more often than their colleagues to serve on panels and committees and in mentoring roles, which may not be weighted as heavily as other metrics for career advancement. Finally, while anyone can be adversely impacted by a workplace environment that crosses from challenging to hostile, individuals who are demographically isolated often have less recourse to disrupt hostile patterns or navigate toward reconciliation. The cumulative effect of these challenges and dysfunctions is a large expenditure of energy in directions that neither advance individuals nor fields of knowledge and innovation in STEM – an inefficiency that taxes the entire discipline, and disproportionally its underrepresented members.

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, Latinx, 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.

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 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

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.

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. **You will begin discussing these focus areas with your team on day 1 of the Inquiry Institute, including the bulleted strategies at the end of each section.**

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.[14] 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.[15,16]

It is not that an ensemble of learners needs multiple ways to participate because the learners have a diversity of fixed "learning styles." In fact, the existence of fixed learning styles and the strategy that instruction should be tailored to them are "neuromyths" and "major myths," debunked with regularity in the literature.[17,18,19,20] Learners "differ in repertoires for engaging in discussions with authority figures, answering known-answer questions, analyzing world problems on the basis of counterfactual premises, seeking or avoiding being singled out for praise, spontaneously helping classmates, responding quickly or pondering ideas before volunteering their contributions… rather than pigeonholing individuals into categories and teaching to the students' 'traits' or attempting to replace those traits, the emphasis [should] be placed on helping students develop dexterity in using both familiar and new approaches."[21] 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. 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. This cannot just be having learners do lots of different things – instructors and mentors must explicitly recognize and validate multiple ways to build and demonstrate understanding. 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,[22] and because cooperative learning can support relations between people from different backgrounds.[23] 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.[24]

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

- **Instructors build into activities multiple opportunities for learners to express their understanding in ways that align with the activity goals.** In addition to simply providing multiple tools or strategies for engaging in the activity, instructors can clearly communicate to students that success in the activity can be attained and demonstrated through these multiple modes. For example, rubrics that clearly indicate measures of success and expectations, but still allow for various demonstrations of knowledge, can be given to learners as a way to allow them to self-monitor their progress while still being allowed multiple modes of participation or demonstration.
- **Instructors carefully construct group work.** 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. Authentic roles for learners to play within the group are either explicitly modeled, or recognized and supported when they emerge on their own. Authentic roles might include detailed work on the problem itself, and also more metacognitive work on project planning, reporting, and presentation. Importantly, these roles should be rotated to prevent students from repeating the same roles that they always take on.
- **The social nature of group work is acknowledged and managed.** Social dynamics in an activity are managed or designed so that no one learner's participation interferes completely with another's. Instructors actively monitor group interactions and make moves to get all learners talking and engaging with materials in meaningful ways, managing the social dynamics and the distribution of materials.
- **Projects give learners multiple approaches to the problem.** Mentors create opportunities for the learner to work on parts of a project with different colleagues, who may work or communicate in different ways. These ways might include detailed technical expertise, and also more metacognitive skills of project planning, management, and presentation.

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.[25] 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.[26] Differences in outcomes between men and women or between White students and racial minority students decrease when learners have an opportunity to reflect on and affirm their values.[27] 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.

Motivation itself is a concept worthy of closer scrutiny.[28] An activity must have some kind of value to the learner. Value can include the activity's intrinsic value (satisfaction from the work itself), its attainment value (satisfaction from the accomplishment of completing the work), and its instrumental value (the work's role in the learner's other goals). In addition to value, the learner must believe they can successfully complete the activity; these beliefs are called expectancies. Expectancies include outcome expectancies (beliefs that the learner's actions will result in a positive outcome) and efficacy expectancies (beliefs that the learner is capable of the work).

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. A powerful view of agency acknowledges the STEM community's role in defining the disciplines' culture, but also highlights the instructor's power to define a separate classroom community culture, and equips learners to apply their knowledge to make a difference.[29] The practices that instructors and mentors use to engage learners are as important as the curriculum itself.[30]

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

- **The inquiry activity highlights potential student value of the learning goals.** In contexting the activity, instructors can be explicit about the connection between the intrinsic value of the activity content, as well as the instrumental connection the activity's content has to learners' long-term educational goals. Separately, the STEM practices learners will improve at in the activity can be explicitly highlighted for their intrinsic and instrumental value.
- **Instructors and mentors are clear about learners' efficacy.** All work takes place in a climate of positive expectancies. Learners can expect that they are capable of identifying and doing the work needed to succeed in the activity and/or project, and that their instructors and mentors will help and guide them.
- The 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.
- A project has multiple possible solution pathways or components of the solution, such that the learner may choose one near the project onset, invoking their goals or interests.
- **The activity recruits students to utilize their interests and values in demonstrating their knowledge** Specific components of an activity may be intentionally designed as to invite learners to make their interests and values explicit and connected to the goals of that component. For example, an inquiry component may ask learners to demonstrate their understanding of the activity content through presenting a solution to problem they were tasked with solving. <u>In addition to facilitating the assessment of learners' progress towards defined learning goals</u>, instructors may actively prompt learners to utilize their own interests, such as how the solution would have an effect on their local community, or include their values as part of the solution, such as how it takes into account ethical concerns.

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.[31] 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.[32,33,34,35] 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.[36] 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.[37,38] A "growth mindset" appears to buffer learners from negative stereotypes about their group(s), which can both improve their performance[39] and their "sense of belonging" in the discipline.[40] (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).[24]

Unconscious biases can affect teaching and learning,[41] as well as views of competency that impact hiring practices and other important aspects of career advancement.[42] 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.

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

- **The activity explicitly conveys positive beliefs about learners' abilities.** The 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).
- **Stereotypical pitfalls are anticipated and carefully navigated.** 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." 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.
- **Opportunities for self-reflection and self-assessment are structured into the activity.** Self-reflection is often a difficult skill for students to engage in and may benefit from

structured prompts that allow students to monitor their own improvement and areas where improvement may be needed. Instructors may build these reflections into the activity as related to an activity goal, and prompt students to monitor where their thinking is currently, and how it has evolved since starting the activity. In addition to building students' metacognition towards science and engineering tasks, this active reflection may help students in acknowledging their progress in difficult tasks and cultivating a growth mindset.
- Opportunities to practice and get feedback on challenging aspects of a project are structured into the learner's overall experience.

4. Developing an identity as a person in STEM

We start with a quote from Chapter 7 of [25] (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." [43] A framework for STEM identity has emerged that emphasizes competence, performance, and recognition.[44] 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 in ways culturally appropriate for STEM. 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.[45,46] 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.[24,29]

Learners' conscious or unconscious beliefs and preferences about how others view them can cause them to "disidentify" when under stereotype threat.[47] 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.[48,44] 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.[8,49] 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[50] or may not,[51] 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.[46] 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.[25] 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.[44]

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

- **The inquiry activity emphasizes and makes practices of science explicit to all learners.** In addition to bolstering conceptual understanding, an inquiry activity can highlight and make explicit goals related to the practices of science, such as explaining results using data. These practices and/or other norms may be introduced early on to the students, and instructors may simultaneously assess progress on these practices in addition to other science content. Students may even be afforded the opportunity to monitor their own progress in such science and engineering practices by being given clear goals and measures of progress towards those goals, such as in the form of a rubric. Importantly, students should still have opportunities to develop their agency in engaging in the practices of STEM.
- **The activity can include opportunities for learners to consider how they would communicate their work in other settings.** To develop STEM identity, it is critical for students to perform for and receive recognition from meaningful others in their STEM fields. Students often also seek recognition from different communities that may bolster their STEM identity, and could benefit from performing for those communities. <u>In addition to having opportunities to perform relevant practices of STEM for meaningful others in their field</u>, students may be asked to consider how they would communicate their work, as an expert, to a group or community that is important to them. Learners reflect on and identify the differences between communication styles. The instructor can wrap up activity by reviewing learning goals, referencing each learner's progress to reinforce their sense of accomplishment and belonging in STEM
- **The inquiry activity is designed to build learners' competence, give them opportunities for performance as their mastery increases, and provide recognition from instructors and peers.** In order to support the development of STEM identities, these three critical aspects of identity are intentionally structured into the activity. A phase, or phases, of the activity includes building competence in ways that are aligned with the learning goals of the activity, including performing STEM practices. Learners are given opportunities to perform this competency in meaningful ways, such as in an authentic application of the content or STEM practices. There would also be a phase where learners are recognized for their contributions. This is not simply praise--this means recognizing that students' diverse ways of demonstrating knowledge are recognized as legitimate contributions towards the goals of the activity and in STEM, in general
- A 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.). The 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.[40] Interest (FA #2) is a crucial component[46] of a learner's STEM identity, in addition to her/his competence, performance, and recognition.[44] Self-efficacy and agency—which relate to learners' self-beliefs (FA #3) and their goals (FA #2) are also hard to disentangle from identity.[24,29]

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.[43]

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, directly quoted text on p. 16 and p. 17, http://ca.cags.ca/documents/killam/killam2003.pdf

[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, https://cepa.stanford.edu/sites/default/files/reardon whither opportunity - chapter 5.pdf

[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, https://ww3.aauw.org/research/why-so-few/

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

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

[13] 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.)

[14] 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.

[15] 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, https://nap.nationalacademies.org/catalog/9853.html

[16] 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

[17] 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

[18] Dembo, Myron H., and Keith Howard. “Advice about the Use of Learning Styles: A Major Myth in Education.” *Journal of College Reading and Learning* 37, no. 2 (March 1, 2007): 101–9. https://doi.org/10.1080/10790195.2007.10850200

[19] Rohrer, Doug, and Harold Pashler. “Learning Styles: Where’s the Evidence?” Medical Education 46, no. 7 (July 2012): 634–35. https://doi.org/10.1111/j.1365-2923.2012.04273.x

[20] Howard-Jones, Paul A. “Neuroscience and Education: Myths and Messages.” *Nature Reviews Neuroscience* 15, no. 12 (December 2014): 817–24. https://doi.org/10.1038/nrn3817

[21] 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

[22] Vygotsky, L.S., 1978. *Mind in Society: The Development of Higher Psychological Processes.* Cambridge: Harvard University Press. https://www.hup.harvard.edu/catalog.php?isbn=9780674576292

[23] 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

[24] 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

[25] 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

[26] 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

[27] 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, https://www.science.org/doi/10.1126/science.1195996

[28] See Chapter 3 and references therein of: Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*, Wiley, https://www.wiley.com/en-us/How+Learning+Works%3A+Seven+Research+Based+Principles+for+Smart+Teaching-p-9780470484104

[29] 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

[30] 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

[31] 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

[32] 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, https://psycnet.apa.org/doiLanding?doi=10.1037%2F0022-3514.69.5.797

[33] 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, https://doi.org/10.1177/0146167202288010

[34] Schmader, T., Johns, M., & Forbes, C., 2008. "An Integrated Process Model of Stereotype Threat Effects on Performance." *Psychological Review* **115** (2), 336–356, https://doi.apa.org/doiLanding?doi=10.1037%2F0033-295X.115.2.336

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

[36] 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, https://doi.org/10.1177/0146167299258011

[37] 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, https://doi.org/10.1006/jesp.2001.1491

[38] Dweck, C.S., 2006. *Mindset: The New Psychology of Success*. New York: Random House, https://www.penguinrandomhouse.com/books/44330/mindset-by-carol-s-dweck-phd/

[39] 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, https://doi.org/10.1016/j.appdev.2003.09.002

[40] 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, https://doi.org/10.1037/a0026659

[41] 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

[42] 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, https://www.pnas.org/doi/pdf/10.1073/pnas.1211286109

[43] 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, https://doi.org/10.1187/cbe.13-12-0241

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

[45] 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

[46] 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

[47] 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, https://doi.org/10.1177/0146167295215003

[48] 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

[49] 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

[50] Marx, D. M., & Roman, J. S., 2002. "Female role models: Protecting women's math test performance." *Personality and Social Psychology Bulletin*, **28**, 1183–1193, https://doi.org/10.1177/01461672022812004

[51] 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, https://doi.org/10.1103/PhysRevSTPER.9.020115