eliminating racism
empowering women
ywca
New York City

Welcome to the ywca™ STEAAMocracy

The Future of STEM *is* Inclusive

Equity Ideas for Women and Girls in Science, Technology, Engineering, and Math

The Future of STEM *is* Inclusive

Equity Ideas for Women and Girls in Science, Technology, Engineering, and Math

Authors: Sharon Liao, Merle McGee, and Bill Nguyen

About the YWCA of the City of New York

Mission

The YWCA of the City of New York is dedicated to eliminating racism and empowering women and promoting peace, justice, freedom and dignity for all.

Vision

The YWCA of the City of New York envisions a day when the diverse women of New York City, once seen as at risk or working poor, can sustain themselves and their families, and are empowered to define and attain their own unique goals and aspirations, contributing to strong communities, building a better New York for everyone.

The YWCA of the City of New York (YW) was started in 1858, based on an idea developed in London a few years earlier. Their mission was to provide a haven for young women — both U.S. and foreign-born — by offering safe housing and educational resources. The organization filled an important void in 19th Century New York and quickly grew. Today's YW is one of the oldest and largest membership organizations in the world. It is independently owned and operated, but connected to a worldwide network of sister YWCAs that serve 25 million people, in more than 125 countries. The YW stands for the elimination of racism and the empowerment of women. The YW focuses its resources on race and gender equity and helping communities in-need, with affordable high-quality childcare and after school programs in New York City. Visit our website www.ywcanyc.org

Dr. Danielle Moss Lee, Chief Executive Officer

Acknowledgements:
Tamara Buckley, Ph.D.
Jaquelynne Eccles, Ph.D.
Ruthe Farmer, MBA
Nadya A. Fouad, Ph.D.
Deidre Franklin, Ph.D.
Jo Handelsman Ph.D.
Kate Krontiris, MBA, MPP
Cristina Morais
Darcy-Tell Morales, Ed.M.
Moinina David Sengeh, Ph.D.
Marcia Tyler, Ed.M.
Jenny Vasquez-Akim, Ed.D.
Barbara Whitten, Ph.D.

Designer: Michael J. Kranz

Table of Contents

Executive Summary

Emboldened by our mission ‘Eliminating Racism and Empowering Women’, the YWCA of the City of New York offers YWSTEAAM™ (Science, Technology, Engineering, Arts, Activism and Math) as an expanded approach to Science, Technology, Engineering and Math education. We set forth a programmatic approach that uses ***Activism*** as an important method to tackle the intrapersonal, interpersonal, cultural and institutional barriers that impede race and gender equity in the STEM field. With this analysis that frames persistent barriers to STEM for marginalized groups, stakeholders can advocate for the use of equity strategies and create classroom and workplace contexts that include practices that enhance science identity, mitigate stereotype threat and implicit bias to level the playing field. By doing so, students, instructors, and employees will have the knowledge and strategies to create real change. YWSTEAAM™ has distilled these essential ideas and practices into a set of equity ideas to further the discourse and strengthen STEM education for women and girls.

In this paper, Welcome to the YWSTEAAMocracy™ 'The Future of STEM is Inclusive', the YWCA of the City of New York examines both the pernicious and innocuous beliefs that hamper our ability to understand STEM disparities in the context of broader unexamined societal patterns of inequity. We believe progressive methods of instruction, such as hands-on learning and real-world application, are deepened with a combined focus on implicit bias, science identity, leadership and social justice. YWSTEAAM™ is a practice rooted in dignity and self-determination that engages a systemic analysis, nurtures 'brave spaces' and rewards reflective practice.

Key Findings

Based on our review of the research, interviews with STEM equity experts and women in STEM majors and careers, we learned that significant work is still required to level the playing field. Although in recent years women have advanced in both education and the workforce, the underrepresentation of women in STEM careers and programs—particularly those from marginalized communities—persists. Our approach to the literature on gender equity in STEM was framed by the three overarching questions: "What are women and girls experiencing inside the classroom? What are women and girls seeking outside the traditional classroom? What can we do to reform workplace environments and STEM culture as a whole?" Our findings settle neatly along these lines.

Inside the classroom, women and girls are experiencing (1) *non-inclusive classroom environments*; (2) *minimal social applications for STEM learning*; (3) *social isolation and limited opportunities to build community*; (4) *limiting leadership opportunities*; (5) r*ace and gender bias and micro aggressions*; and (6) *primarily single-discipline pedagogy*.

Outside the classroom, extracurricular programs provide (1) *communities and near-peer mentoring*; (2) *real-world applications to learning*; (3) *exposure for girls to diverse role models and clear career pathways*; (4) *leadership opportunities and skill development via collaborative projects*; and (5) *STEM activities that link to social impact*.

Workplaces must pay more attention to (1) *unspoken norms*; (2) *support networks for women*; (3) *lack of transparency in work place values, policies and expectations*; and (4) *meaningful recognition of women's contributions*.

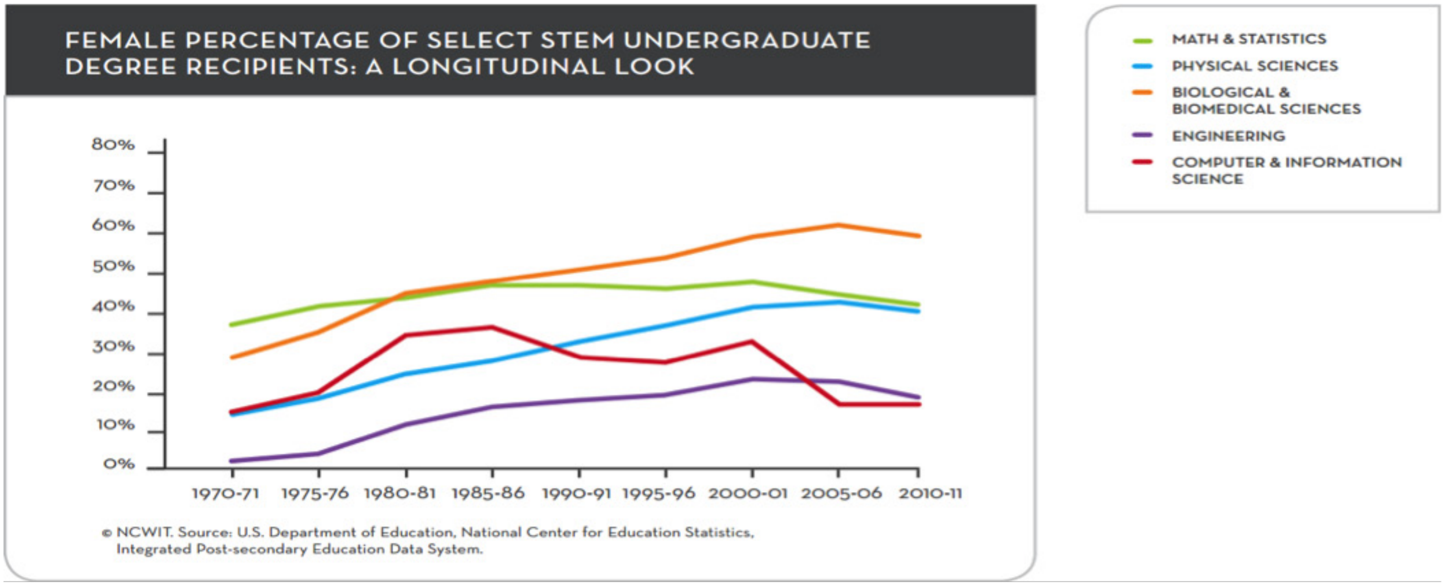
A culture shift in STEM would require (1) r*eevaluating normative behavior*; (2) *mitigating implicit bias*; and (3) *holding responsible parties accountable for enacting equitable policies and practices*.

YWSTEAAM™ Model

YWSTEAAM™, based on primary and secondary research, asks readers to consider a set of equity ideas to strengthen STEM education for women and girls. Our model intentionally embeds these core ideas into our curriculum framework, teaching strategies, classroom environment and the general ethos of the program. Our equity approach includes:

- ***Hands-on/real world application;***
- ***Intentional cultivation of science identity;***
- ***Explicit gender and race inclusive practices;***
- ***Community building and near peer mentoring;***
- ***Leadership development;***
- ***Social justice awareness;***

We hope that the YWCA of the City of New York's endeavors will not only empower young women to pursue and persist in rewarding STEM careers, but also raise cultural and institutional awareness about the urgency of making STEM more equitable. Our goal is to disrupt the status quo, contribute to current dialogue, apply equity best practices and animate those difficult, but extremely important, culture shifts. It's time for us to recognize that as a society the problem is not with our women and girls, but with the cultures we are asking them to mold and fit themselves into.



From Girls in IT: The Facts, a report by the National Center for Women and Information Technology.

Introduction

There are cultural, social, and personal factors that systematically discourage women from entering STEM fields, including pernicious stereotypes and work environments virtually devoid of women. Women have held less than 25% of STEM jobs in the past decade, even though math and math-related careers routinely count among the highest-paid careers. Furthermore, the U.S. Department of Labor reports that because of continuing worker shortages in these fields, corresponding employment opportunities are poised to grow much faster than average through 2018. If girls are not encouraged to explore STEM careers, the gender gap in filling them will continue to widen. Retaining women isn't just a matter of economic demand, It's also a matter of gender equity and social progress. In this report you will find an equity approach and strategies, supported by our research, designed to significantly enhance the experience of women and girls in a variety of STEM settings.

What is the YWSTEAAMocracy?

The YWCA of the City of New York offers the YW STEAAM™ (Science, Technology, Engineering, Arts, Activism and Math) as an expanded approach to Science, Technology, Engineering and Math education. We set forth a programmatic approach that uses ***Activism*** as an important method to tackle the intrapersonal, interpersonal, cultural and institutional barriers that impede race and gender equity in the STEM field. With this analysis that frames persistent barriers to STEM for marginalized groups, stakeholders can advocate for the use of equity strategies and create classroom and workplace contexts that include practices that enhance science identity, mitigate stereotype threat and implicit bias to level the playing field. By doing so, students, instructors, and employees' will have the knowledge and strategies to create real change. YWSTEAAM™ has distilled these essential theories and practices into a set of equity ideas to further the discourse and strengthen STEM education for women and girls.

Our model purposely embeds these core ideas into our curriculum framework development, teaching strategies, classroom environment and the general ethos of a STEM setting. Our equity approach includes: ***Hands-on/real world application; Intentional cultivation of science identity; Explicit gender and race inclusive practices; Community building and near-peer mentoring; Leadership development; and Social justice awareness.***

An Equity Approach

The enhanced YWSTEAAM™ model intentionally applies six (6) core principles to our pedagogy in an effort to embody a social justice and equity framework. The YW believes embedding these practices in curriculum development, teaching strategies, classroom environment and the general ethos of institutions will improve the experiences of women and girls and other underrepresented groups in the field.

(1) **Hands-on/real world application**; our strategy utilizes interdisciplinary experiential instructional methodologies such as observation, experimentation, construction and art to apply knowledge to real world issues and includes the dissemination of new knowledge.

(2) **Intentional cultivation of science identity**; developing a science identity includes promoting a growth mindset and congruence among various personal identities. Growth mindset rejects a fixed belief in knowledge and focuses on one's ability to learn. A metacognitive exploration of identity can reconcile various identities with a science identity and explicitly explores how one socially and emotionally connects to the materials.

(3) **Explicit gender and race inclusive practices**; addresses implicit bias, unexamined institutional norms that privilege dominant groups and eliminates biases in instruction, practices and classroom environment. Strategies to support inclusive practices include ongoing training, dialogue, reflection and exposure to a range of scientific 'possibility' models.

(4) **Community building and near-peer mentoring**; identity affirming strategies such as collectives, affinity spaces and nurture supportive relationships and positive peer influences to promote persistence. Near-peer mentoring and role modeling supports learning and fosters motivation with the community subgroups.

(5) **Leadership development**; educators/leaders foster leadership through individual and group self-directed projects. Careful examination of group dynamics, leadership styles that stretch students' perceptions of confidence and agency.

(6) **Social justice awareness**; curriculum/projects consider social impact, address real-world issues and encourage personal accountability to take action within one's own community.

Central to YWSTEAAM™ is the nurturing of brave spaces. Within brave spaces communities foster psychologically and emotionally safe spaces that ensure mutual respect while encouraging growth through transparency, accountability, and authenticity. Brave spaces embrace conflict and discomfort while promoting the courage to struggle for new understanding. Brave spaces act as incubators of equitable spaces to grapple with deeply entrenched beliefs and unexamined norms to advance necessary conversations and actions.

Based on primary and secondary research, this report will outline aspects of inequality within learning and workplace domains that we believe can be addressed with the application of the YW STEAAM™ model.

Where We Are Now: Data and Context

Strengthening the STEM workforce has become a critical plank of our national economic agenda, and at the moment, our country is not keeping up with the demand for more STEM professionals. President Obama has declared that the American economy needs 1 million more STEM graduates by 2022 for the country to retain its preeminence in scientific innovation. Meeting this goal requires increasing the number of STEM graduates by 34% annually. Increasing the retention of STEM majors from 40% to 50% would only generate three quarters of the 1 million desired.[1] The attrition of women from STEM fields happens at all stages—during adolescent development, in universities, and in the workplace. Women have made remarkable gains in education and in the workforce over the last few decades—but progress in the fields of science, technology, engineering, and math (STEM) have been uneven. While women now earn as many degrees in biology, chemistry, and math as men, progress has stalled in technology and engineering—and even receded in the area of computer science.[2] In 1984, women represented 37% of computer science graduates. Today, they constitute only 12%.

Women are outnumbered by men in undergraduate STEM studies, but even more so once they enter the workforce. Women only earn 19% of bachelor's degrees in engineering.[3] High-tech companies report especially egregious attrition rates, as 56% of female employees leave within 10 years.[4] The world of academia is male-dominated too. Despite earning more biology degrees than men, women still hold only one third of biology faculty positions. This number drops to 22% in computer science faculty, 19% in math, 18% in the physical sciences, and 12% in engineering.[5] Women, especially women of

---

1 "Report to the President — Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics," President's Council of Advisors on Science and Technology, 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

2 "Women in Engineering: A Review of the 2012 Literature," Society of Women Engineers. http://www.nxtbook.com/nxtbooks/swe/litreview2012/#/226

3 "Science & Engineering Degree Attainment: 2004-2014," National Student Clearinghouse, 2014. http://nscresearchcenter.org/snapshotreport-degreeattainment15/

4 "Women in IT: The Facts," National Center for Women and Information Technology, 2010: 11. http://www.ncwit.org/sites/default/files/legacy/pdf/NCWIT_TheFacts_rev2010.pdf

5 "Why So Few? Women in Science, Technology, Engineering, and Math," The American Association of University Women, 2010: 15. http://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

color, remain severely underrepresented at all levels of academia and in all areas of the STEM workforce.

The Society of Women Engineers has published an annual literature review for over a decade, "Women in Engineering," lamented the "Groundhog Day" quality of tracking progress year to year:

> Each year, we find ourselves reviewing many of the same issues, describing the same unresolved questions, summarizing similar studies, similar findings, and a general lack of agreement among the researchers as to what is happening, or what the solution may be to increase the numbers of women in engineering.[6]

Achieving sustainable reform in STEM education and workplaces requires us to focus on environmental and institutional factors rather than student deficiencies. How can we address the root causes of the gender gap? What reforms must we make, and what steps can we take to level the playing field?

This report summarizes the most compelling research and explanations regarding barriers to entry and persistence for girls and women in STEM, especially in technology, engineering, and physics. The dearth of women is most dire in these three areas, where women still represent less than 20% of the workforce. According to the Congressional

6 "Women in Engineering," page 224.

Joint Economic Committee women only make up 14% of engineers. This figure, although factual, understates the lack of American women in the field, as companies are recruiting more female engineers from overseas. On the other hand, women have reached or exceeded 50% in the life sciences (i.e., biology and chemistry), and are close to parity in math. We will examine and explain these differences across fields.

Women encounter bias and discrimination throughout their STEM journey; which one female Google engineer characterized it as a "death by a thousand cuts."[7] Retaining more women in STEM is not only a matter of economic demand but also one of gender equity and freedom.

Identity and Science

In contrast to fields like literature and history, science is reputed to be a "culture of no culture," where objectivity reigns supreme.[8] From broad strokes like the scientific method to logistical details like multiple-choice exams, many elements reinforce the belief that the world of STEM is fair— that everyone willing to adopt its standards enjoys the same chance at educational and professional success.

> "The problem with gender is that it prescribes how we should be rather than recognizing how we are. Imagine how much happier we would be, how much freer to be our true individual selves, if we didn't have the weight of gender expectations."
>
> Chimamanda Ngozi Adichie

But at least since the 17th century, "when the great scientific revolution we associate with people like Isaac Newton" began to spotlight white male scientists in the Western world, science has privileged particular ways of being that force many women— especially women of color—to compromise their identities in service of crafting a palatable image.[9] To understand this compromise, we might consider W.E.B. DuBois's idea of double consciousness:

> It is a peculiar sensation, this double-consciousness, this sense of always looking

7 "Google Engineer: Being A Woman In Tech Is Like Dying By A 1,000 Paper Cuts," Megan Rose Dickey, 2013. http://www.businessinsider.com/being-a-woman-in-tech-2013-3

8 Ong, Maria. "Body Projects of Young Women of Color in Physics: Intersections of Gender, Race, and Science." Social Problems 52, no. 4 (November 1, 2005): 593–617.

9 "How 'The West' Beat 'The Rest' with Six 'Killer Apps.'" NPR. NPR, 2 November 2011. Accessed 22 July 2014.

> at one's self through the eyes of others, of measuring one's soul by the tape of a world that looks on in amused contempt and pity. One ever feels his twoness—an American, a Negro; two souls, two thoughts, two unreconciled strivings; two warring ideals in one dark body, whose dogged strength alone keeps it from being torn asunder. [10]

In a 2005 study, Maria Ong of the Technical Education Research Center (TERC) alludes to double consciousness: Women of color in physics must view themselves through the eyes of others in the physics community.[11]

How does this mindset manifest itself from day to day? Some women take on subordinate positions because of "clashes in temperament, being subjected to ridicule, fears that their partners didn't respect them, and feelings that their partners understood far more than they."[12] Others fracture their identities, presenting and performing a self whom they feel would be acceptable to the scientific community. Still others turn to multiplicity, switching among different layers of identity depending on the situation.

Equity Idea: Gender and Race Inclusive Practices

- Acknowledge personal bias
- Embed practices to mitigate implicit bias
- Offer diverse possibility models

Yet even if these methods have their merits, they share a fatal flaw in placing the burden of adaptation on the individual woman and preventing her from functioning wholly and without artifice. In other words, these methods fail to address the cultural and institutional suppressants at play.

One of these suppressants is stereotype threat, first described by Steele and Aronson as the anxiety experienced when a person is "at risk of confirming, a self-characteristic, a negative stereotype about one's group."[13] According to a 2010 report by the American Association of University Women (AAUW), girls may try to avoid judgment by negative stereotypes—for instance, that girls aren't good at math—by avoiding STEM fields or

---

10 Du Bois, W.E.B. The Souls of Black Folk. New York: Dover, 1994.

11 Ong, Maria. "Body Projects of Young Women of Color in Physics: Intersections of Gender, Race, and Science." Social Problems 52, no. 4 (November 1, 2005): 593–617.

12 Ibid.

13 Steele, Claude M., and Joshua Aronson. "Stereotype Threat and the Intellectual Test Performance of African Americans." Journal of Personality and Social Psychology 69, no. 5 (November 1995): 797–811.

claiming that they aren't interested.[14] Moreover, the consequences extend beyond the visible realm, forcing women and girls who are particularly cognizant of hurtful stereotypes to shoulder the cognitive and emotional burden of science anxiety.[15]

In the same report, the AAUW alludes to another major suppressant: implicit bias, or "the attitudes or stereotypes affecting our understanding, actions, and decisions in an unconscious manner."[16] Project Implicit, a multi-university research collaboration, revealed that most people unwittingly associate math and science with "male" and the arts and humanities with "female."[17] Social settings—schools and workplaces—further complicate this association by introducing the quality of likability. That is, women who exhibit competence in a "masculine" job—who defy implicit bias—are considered less likable, which puts women in STEM in a double bind because both likability and competence are required for workplace success.[18]

Equity Idea: Cultivation of Science Identity

- Foster growth mindset
- Focus on one's ability to learn
- Make and model 'room for mistakes'
- Explicitly connect learning to students lives

Despite these barriers, research by Heidi Carlone and Angela Johnson on science identity points to a potential area for intervention. Their model analyzes science identity along three dimensions: competence (knowledge and understanding of content), performance (social demonstration of relevant scientific practices), and recognition (acknowledgment, both by oneself and others, as a "science person").[19]

14 Hill, Catherine, Christianne Corbett, and Andresse St. Rose. "Why So Few? Women in Science, Technology, Engineering, and Mathematics." AAUW: Empowering Women Since 1881. 2013. http://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

15 Ibid.

16 "Understanding Implicit Bias." Kirwan Institute for the Study of Race and Ethnicity. Accessed 10 July 2014. http://kirwaninstitute.osu.edu/research/understanding-implicit-bias/

17 Hill, Catherine, Christianne Corbett, and Andresse St. Rose. "Why So Few? Women in Science, Technology, Engineering, and Mathematics." AAUW: Empowering Women Since 1881. 2013. http://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

18 Ibid.

19 Carlone, Heidi B., and Angela Johnson. "Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytic Lens." Journal of Research in Science Teaching 44, no. 8 (October 1, 2007): 1187–1218.

By a significant margin, recognition from others is the critical factor in forming a science identity.[20] Although women may be able to envision themselves in many capacities within academic science, it is ultimately the scientific community's responsibility to recognize them in meaningful ways and to combat discrimination. Science identity, after all, is both intrapersonal and interpersonal. "Being somebody" requires consensus, and consensus requires the participation of others.

According to physics professor Jeffry Mallow, everyday practices can mitigate science anxiety and build science identity in the classroom.[21] Mallow suggests that instructors tailor their curricula to include science skills—to push students past memorizing facts and on to transferable techniques like solving word problems, taking notes, and performing in laboratories. Likewise, he encourages instructors to emphasize metacognition—the process of thinking about how we think—so that doing well in science seems less mysterious and more methodical. In tandem with science skills and metacognition, group work and theme-based curricula can help to enhance interest and performance by engaging students with each other and with real-life applications. Of course, group work isn't the only way to expose students to creative learning—demonstrations and even writing exercises can be just as fun and interactive.

Equity Idea: Community Building and Near-Peer Mentoring

- Nurture supportive relationships
- Leverage positive peer pressure to promote persistence
- Amplify 'creditability' through leadership opportunities

Besides curriculum, there are interpersonal elements to nurturing confidence among women and girls in academic science. Instructors should distribute questions equally to students of both genders, perhaps by keeping a written record, and allow students ample time to formulate their answers. If students are struggling with the material, then instructors should engage in Socratic dialogue, tracing back to the last concept the students did understand and working from there. That way, students can develop a growth mindset—they'll see science as a process of exploration and a mode of inquiry, not as an arena where either they have the answer or they don't. Furthermore, although collaboration is key to learning, it doesn't always mean that everyone is participating in similar capacities. Monitoring group work is necessary to promote gender-equitable

20 Ibid.

21 Mallow, Jeffry V. "Science Anxiety: Research and Action." Handbook of College Science Teaching. Arlington, VA: NSTA, 2006. 3–14.

behavior or, in Mallow's words, "to make sure that groups are not divided into scientists and secretaries."[22] Finally—and arguably most importantly—instructors need to balance content and relationship when interacting with students. "Body language, tone of voice, word selection, and classroom organization"—such subtle details have historically favored men and boys in teacher-student interactions, so it's imperative that instructors remain cognizant of their own biases.[23] Many other ways exist to build identity and reduce anxiety among women and girls in STEM, not only in education, but also in the workplace and in our world at large. These settings are discussed in greater detail within the paper.

Barriers in Education

The belief that "girls just aren't interested in science" is an inaccurate, widely held misconception that obscures the systemic barriers for girls in STEM education. Research tells us that girls are interested in science, and just as much as boys are.[24] The barriers for girls in science education are multidimensional and embedded in classroom pedagogy, curriculum, faculty bias, and academic culture.

22 Ibid.

23 Ibid.

24 See Girls Scout report, Generation STEM.

Eileen Pollack, one of Yale's first female physics majors, graduated at the top of the department in 1972, but did not apply to graduate school because of discouragement from her professors. Pollack, who is now a freelance writer, spent the last couple of years speaking with women currently studying or working in physics, and was dismayed to find that the state of women in STEM has not changed:

> The cultural and psychological factors that I experienced in the '70s not only persist but also seem all the more pernicious in a society in which women are told that nothing is preventing them from succeeding in any field. If anything, the pressures to be conventionally feminine seem even more intense now than when I was young.[25]

> "Many young girls do not pursue careers in engineering, computer science and physics because they do not see a strong relationship between what one does in these careers and the kinds of things they would like to accomplish in their careers."
> Dr. Jacquelynne Eccles, University of California, Irvine

Discrimination against women in science today takes different forms than it did in the 1970s, but is no less real or intense. As Pollack says, this "sexism isn't a problem anymore" attitude tells girls that nothing is holding them back and that when they experience hardship, it's their fault.

Effective STEM education assists students in developing their science identity alongside their technical and academic skills. Jennifer Skaggs, in her paper on the integration of gender into STEM education, writes, "When females believe their personality and skills are good matches for their environment, their self-efficacy and commitment to academic [or work] environment increases."[26] Indeed, psychologists have shown that individuals choose professions based on personal values and expectations for success.[27] To make science accessible to girls, educators need to provide multiple ways for them to "be in science"—to engage with the material and envision themselves succeeding in a science profession.

25 Pollack, Eileen. "Why Are There Still So Few Women in Science?" The New York Times. 3 October 2013. Sec. Magazine.

26 "Making the Blind to See: Balancing STEM Identity with Gender Identity," Jennifer Skaggs, July 2011.

27 Eccles, Jacquelynne. "Gendered Educational and Occupational Choices: Applying the Eccles et Al. Model of Achievement-Related Choices." International Journal of Behavioral Development 35, no. 3 (May 1, 2011): 195–201.

Science in society. Psychologists' research has shown that women tend to prefer work with a clear social purpose, but most people do not view STEM careers as directly benefiting society or other people.[28] Certain STEM disciplines with a clearer social purpose (e.g., biomedical and environmental engineering, life sciences) have attracted more women than fields like physics or electrical engineering. Teachers can more actively engage female students by connecting scientific or mathematical concepts to real-world examples and problems. Women who leave computing or engineering often cite a disconnect between class content and real-world applications. As an example, group projects about solving contemporary problems have multiple benefits for all students: They stimulate interest in creative problem solving, show students the impact they can have as engineers, and gives them experience with collaborating.

Equity Idea: Hands on/ Real World Applications

- Contextualize the problem to be solved
- Make it 'real' by using experiential learning opportunities
- Encourage creative mix method approach to problem solving
- Offer opportunity to solve real world issues

Teachers can also incorporate real-world examples into daily lesson plans. Math teacher Ann Pollina teaches transformation and isometry in her high school geometry class using decorative borders from different cultures.[29] At the college level, professors Jo Handelsman and Barbara Whitten recommend that introductory science courses incorporate real-world applications of lofty theories or abstract concepts. Women with altruistic career ambitions are more likely to persist if STEM aligns with their goals of contributing to society.[30]

Interdisciplinary pedagogy. At its core, science is about the spirit of discovery—and the mark of a successful scientist is the construction of knowledge, not the absorption of it. Science is everywhere, and, at its best, science education challenges students to

---

28 Eccles, Jacquelynne, S.J. Ceci, and W.M. Williams. "Where are all the women? Gender differences in participation in physical science and engineering." In Where aren't more women in science? Top researchers debate the evidence. Washington, DC: American Psychological Association, 2006.

29 Pollina, Ann. "Gender Balance: Lessons from Girls in Science and Mathematics." Educational Leadership 53, no. 1, September 1995.

30 Espinosa, Lorelle L. "Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence." Harvard Educational Review, 2011.

engage in conceptual and critical thinking, identify patterns, and draw connections.

STEM education should engage students' quantitative skills in harmony with their critical thinking and verbal skills. Research studies have shown that students with both strong math and verbal skills are less likely to pursue STEM careers than those with high math skills and moderate or low verbal skills. Among men and women with similar math abilities, women are likely to have stronger verbal abilities.[31] In short, STEM fields are losing the most well-rounded students and potential innovators. This pattern of attrition has serious implications for science education: How can STEM education engage students' verbal skills and creativity? How can we orient math and science to attract students who also like the humanities and social sciences?

One reason the humanities and social sciences attract young people is that they teach transferable skills that can address a host of diverse conceptual issues and social problems. In her study of underrepresented racial minority (URM) undergraduate women in STEM, Lorelle Espinosa found that science education lacks critical pedagogy, or teaching that engages students in thinking critically about their surroundings:

> Equity Idea: Social Justice Awareness
> - Discuss the social impact of a STEM problem
> - Value 'lived experience' as data in STEM research
> - Create opportunities to problem solve issues affecting students' lives

> If women are finding other disciplines or related course content more relevant to their day-to-day life and worldview, they are likely to switch majors, marking an incredible lost opportunity for STEM disciplines.[32]

For students to see science as part of their world, educators must give them opportunities to discuss science in broader social contexts and examine science's relationship to social justice, oppression, and power. One way to engage students, especially girls, in critical pedagogy is to integrate feminist and critical race theory and discuss the role of gender and power in science. Espinosa suggests that educators relate science to understanding social structures and systems of power, as well as who the students are and

31 Wang, Ming-Te, Jacquelynne S. Eccles, and Sarah Kenny. "Not Lack of Ability but More Choice Individual and Gender Differences in Choice of Careers in Science, Technology, Engineering, and Mathematics." Psychological Science 24, no. 5 (May 1, 2013): 770–75. doi:10.1177/0956797612458937.

32 Espinosa 233.

who they want to be—this might mean trying interdisciplinary curriculum across departments of STEM, education, and gender and ethnic studies. Interdisciplinary work presents opportunities for students not only to create technology or make scientific discoveries, but also to apply it to social change.

This interdisciplinary, critical approach is also found in STEAM—or STEM education integrated with the arts. However, with the addition of activism (social justice awareness), YWSTEAAM™ education encourages creative innovation and action through the 3 D's: discovering, designing and developing. This approach empowers students to act as creators, activists and disseminators of technology and to apply their abilities as they would in the arts and humanities. In 2013, MS 534 in Brooklyn garnered the attention of The Wall Street Journal and educators nationwide when students in a photography class built their own cameras.[33] While these types of hands-on, interdisciplinary projects open up students' imaginations, teach flexible thinking and risk taking, the addition of activism would provide a 'subject' for students to examine. When technical skills and a social justice analysis are integrated students may experience the personal agency needed to address issues pertinent to their own lives.

Equity Idea: Gender and Race Inclusive Practices

- Accept that implicit bias is embedded in instructional methodology and institution
- Root out implicit bias through training, reflection and discussion
- Embed equity primes to test for bias in institutional culture and practices

Recognizing personal bias. Through language, examples, and everyday interactions with students, teachers often unintentionally favor male students. Implicit bias manifests itself in how teachers evaluate student performance, provide feedback, and interact on a daily basis. Research shows that, from preschool through college, teachers interact more often and in more detail with boys than with girls, asks males more detailed questions that call for higher-order thinking, gives them more feedback (e.g., praise, criticism, correction), and provide them more valuable and specific comments. Tindall and Hamil note the impact of teachers' expectations on their instructional practices:

> Teachers also often exhibit higher expectations for boys, expect them to be better

33 Hollander, Sophia. "STEAM Blends Science and the Arts in Public Education." Wall Street Journal, December 3, 2013, sec. New York. http://online.wsj.com/news/articles/SB10001424052702304747004579224003721262792.

> problem-solvers, and disparately encourage them to engage in problem-solving activities (Graham, 2001). As girls progress through the grades, they have less and less to say. By the time they reach college, men are twice as likely as girls to initiate comments. By the time girls complete high school they have received 1,800 fewer hours of attention and instruction than boys (Woolfolk, 1998).[34]

Due to stereotype threat and social cognitive factors, girls generally do not expect to do as well as their male peers in science and thus often need more encouragement than boys.

34 Tindall, Tiffany, and Burnette Hamil. "Gender Disparity in Science Education: The Causes, Consequences, and Solutions." Education 125, no. 2 (Winter 2004): 282–95.

A 2012 study by Dr. Jo Handelsman and others found that science faculty, both male and female, exhibited a strong gender bias in reviewing identical student applications from "John" and "Jennifer" for a lab manager position:

> Our results revealed that both male and female faculty judged a female student to be less competent and less worthy of being hired than an identical male student, and also offered her a smaller starting salary and less career mentoring.[35]

Students rely on feedback from others to calibrate their own expectations and self-worth, so faculty bias about student competence very likely shapes students' self-efficacy and perceptions of ability.

However, we must be careful not to place blame solely on teachers for flawed educational institutions or for the host of socio-cultural factors driving girls away from STEM. The gender dynamics in classrooms reflect the values, stereotypes, and norms of our society and culture:

> Because classrooms are microcosms of society, mirroring its strengths and ills alike, it follows that the normal socialization patterns of young children that often lead to distorted perceptions of gender roles are reflected in the classrooms.[36]

Recognizing implicit bias is the first step to eliminating it. School and university administrations are responsible for providing teachers with training on gender awareness and providing resources for them to revise curriculum or teaching practices. On the path to reforming gender biases in academic culture (and ultimately our culture at large), educators must build classroom environments that foster inclusion and identity safety.

Equity Idea: Leadership Development

- Rotate leadership roles
- Use praise to lend creditability to non-dominate groups
- Value contribution of each role on the team

Gender-inclusive practices. In contrast to a "one size fits all" approach to teaching, differentiated instruction allows educators to engage different student learning styles and

35 Moss-Racusin, Corinne A., John F. Dovidio, Victoria L. Brescoll, Mark J. Graham, and Jo Handelsman. "Science Faculty's Subtle Gender Biases Favor Male Students." Proceedings of the National Academy of Sciences, September 17, 2012, 201211286. doi:10.1073/pnas.1211286109.

36 Marshall, C.S. and Reihartz, J. (1997) Gender issues in the classroom. Clearinghouse, 70 (6), 333-338.

needs. Compared to other subjects, science curriculum tends to include the least variety of differentiated instruction, or teaching that provides different avenues to learning. Research shows that teachers tend to “choose classroom activities that appeal to boys’ interests and to select presentation formats that disparately promote learning in boys.”[37] Teachers can appeal to the interests and preferences of both genders by diversifying their examples, activities, and practices. In physics textbooks, a classic word problem on the laws of motion would involve the path of a baseball or Michael Jordan’s jump shot. More engaging activities would be gender-inclusive and, if possible, apply to real-world problems. Teachers should “choose their metaphors carefully, and have students develop their own.”[38]

Teachers should evaluate their expectations, verbal and physical cues, and messaging in the classroom to assess how they might unintentionally treat male and female students in different ways. For example, when facilitating discussions, teachers can keep track of how often male and female students speak, and make sure that students treat each other as equal participants in the classroom. Teachers can also assess if roles are designated equitably in group activities, as girls and women are often assigned the passive secretarial tasks (i.e. recording data, making the poster) while boys and men typically execute the hands-on, technical roles (i.e. handling equipment, dissecting).

Academic culture and integration. For students to see themselves as scientists and legitimate science students, they need to earn recognition and participate in a science community. Espinosa found, in her study of underrepresented minority (URM) undergraduate women in STEM, that academic integration and interpersonal interactions were the most important factors of persistence. Academic integration, the process of becoming part of a campus community and feeling like you belong, depends on a wide range of experiences: relationships with peers and teachers inside and outside of the classroom; satisfaction with course content and its relevancy; science exposure and research experience; joining a major-related club or organization; and overall insti-

Equity Idea: Cultivation of Science Identity

- Explicitly reflect on how students construct their various aspects of their identity
- Intentionally affirm each student’s abilities and contributions
- Destigmatize knowledge gaps

37 Ibid.

38 Pollina, Ann. “Gender Balance: Lessons from Girls in Science and Mathematics.” Educational Leadership 53, no. 1, September 1995.

tutional setting.[39]

These environmental factors are critical for the persistence of URM women, who frequently struggle to establish and maintain academic integration. In the words of G.J. Campbell, our failure to solve the attrition problem of women and minorities from STEM "stems from an overemphasis on the student deficit model and under emphasis on institutional deficiencies."[40] The historic underrepresentation of women, especially women of color, in STEM studies makes it difficult for minority students to achieve the same level of academic integration as white or male students:

> Women of color in STEM confront a myriad of systemic barriers resulting from an academic culture reinforced by elite, White men as authoritative, determinist, and with pretense to objectivity and neutrality.[41]

For young women to persist in STEM, they must develop a "science identity" that complements other dimensions of their identities, including gender, race, ethnic, sexual, or religious identities. The social and academic environment must provide identity safety for women to embrace, and be embraced by, their STEM setting. As mentioned in earlier sections, "science identity" development requires recognition—recognition of oneself as a legitimate scientist and recognition from others. Science identity is both intrapersonal and interpersonal—being "somebody" requires the participation of others.

Equity Idea: Community Building and Near-Peer Mentoring

- Create identity affirming communities and spaces with your institution
- Foster communities of collaboration
- Formalize near-peer mentoring opportunities

Students who build relationships with professors earn meaningful recognition and validation as legitimate science students. Sociology tells us that women tend to value interpersonal interaction more than men, meaning that these teacher-student relationships are integral to academic integration. Accessing professors, most of whom are white men, can be difficult for women of color. As Espinosa states, "young women of color in science have to carry out a tremendous amount of extra, and indeed, invisible work to gain acceptance from their male physics peers and faculty."[42] On the contrary, White women re-

39 Espinosa 214.

40 Espinosa 215.

41 Espinosa 212.

42 Espinosa dissertation 27.

ported more interaction with faculty outside of class and experienced far fewer instances of faculty expressing racial/ethnic stereotypes in class, compared with women of color.

Inequality at the institution-level is also an important predictor of persistence, with large, public, predominantly white universities revealed as the most hostile climate for women of color, especially those that lack racial diversity on campus and in their faculty. More research focused institutions use competitive grading practices to "weed out" students in introductory classes. Competitive curves and harsh grading practices disproportionately discourage women, who are more likely to underestimate their abilities because of stereotype threat. The "Why So Few" report recommends that professors clarify performance standards and expectations:

> The same letter or number grade on an assignment or exam might signal something different to girls than it does to boys. By using phrases like, "If you got above an 80 on this test, you are doing a great job in this class," teachers help students understand their grades so that students don't have to rely on stereotypes to create a standard for themselves. The more that teachers and professors can reduce uncertainty about students' performance, the less students will rely on stereotypes to assess themselves.[43]

A heightened competitive culture can also be threatening to women who are often socialized to value collaboration and relationship-building, as well as students of color, who face additional obstacles when transitioning to college in their first year.[44]

Peer support networks promote academic and social integration for women, especially women of color, and provide them with opportunities for leadership, mentorship, and recognition. In Espinosa's research, women of color who joined a major-related club (e.g. Society of Women Engineers, National Society of Black Engineers, etc.) and discussed course content with peers outside of class could draw support from a peer group and were significantly more likely to persist in STEM.[45]

Historically Black Colleges and Universities (HBCUs) and campuses that serve students of color have excelled in creating a supportive climate for female scientists. In her study of undergraduate physics departments, Barbara Whitten found that HBCUs make it a

43 Hill, Catherine, Christianne Corbett, and Andresse St. Rose. "Why So Few? Women in Science, Technology, Engineering, and Mathematics." AAUW: Empowering Women Since 1881. 2013. http://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

44 Espinosa dissertation 148.

45 Espinosa 231-232.

priority to support students who aspire to major in STEM, regardless of their background. This welcoming environment is clearly successful: 75% of today's African-American female scientists earned their bachelor's degree at HBCUs.[46]

Key features of the HBCU academic environment include high expectations for student success, alternative routes to entering STEM majors, stigma-free attitudes towards remedial coursework, and supportive student-faculty relationships. These schools build strong networks of support by involving students in research and departmental events from the beginning, connecting students with alumni, and providing alternative routes to starting out in science. Instead of assuming that freshmen are ready to jump into calculus or engineering, HBCUs offer background courses in math and physics—at HBCUs there's no stigma attached to starting at a lower level.

Whitten's recommendations for "warming up" undergraduate physics departments include: recruiting diverse faculty, engaging introductory students with relevant curricula, and promoting mentorship and faculty interaction. Departments can foster a student-oriented culture by providing a student lounge, offering a tutorial service, using student lab assistants, scheduling social events, and supporting major-related clubs.

46 Whitten, Barbara L., Suzanne R. Foster, and Margaret L. Duncombe. "What Works for Women in Undergraduate Physics?" Physics Today 56, no. 9 (September 2003): 46–51.

UNSPOKEN NORMS

At Company P, male engineers typically don a three-piece outfit: polo, jeans, and tennis shoes. If she's lucky, Tay might spot some pressed khakis or boat shoes, but these sightings are rare as they are confusing. "It's hard to figure out what to wear as a woman," she confessed. "I can't just put on blue jeans and bad shoes. It looks sloppy. And once I wear something, it's hard to switch it up. Having people looking at you differently for wearing heels or changing up your hair—guys don't get that. Women do."

Working in STEM Settings

Tay's clothing conundrum may sound innocuous, but it speaks to a much more troubling pattern of behavior—both at Company P and in many other technology and engineering workplaces. As Cindy, a STEM education leader, puts it, "you're expecting a certain level of disproportion. You're expecting a lot of men because that's the cultural norm."

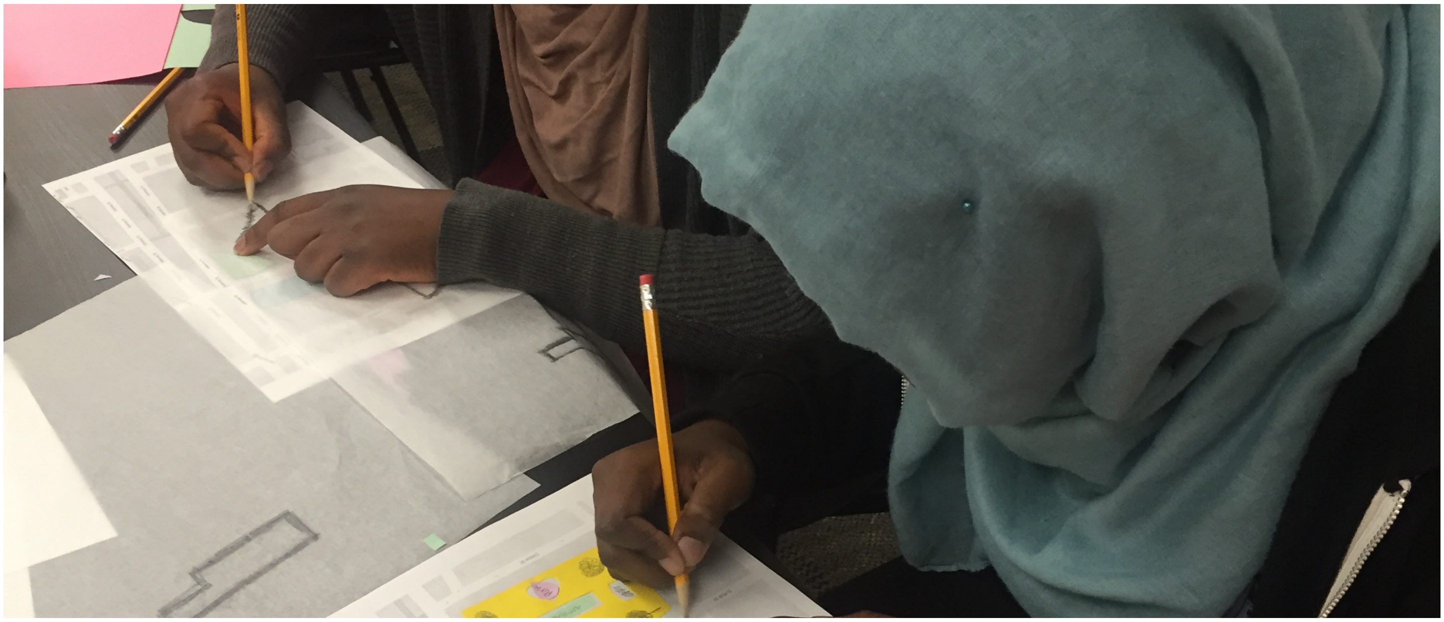
It's a self-perpetuating paradigm: The presence of more men than women generates a culture that attracts more men than women—and dress code is just the tip of the iceberg. According to the U.S. Department of Commerce, women fill only 24% of STEM jobs despite making up 48% of the workforce. For engineering alone, this statistic falls to as low as 11%. Even in seemingly progressive workplaces—ones that employ more women than average—the problem is far from being solved. A major tech company touts a 30% female employee base. But what does that figure mean when it rises to 48% in human resources yet drops to 17% in the more tech-focused departments? And in the event that this tech company did reach gender parity within all departments, how much weight would such progress hold in the absence of workers of color—especially black and Hispanic workers?

Without question, the obstacles facing female STEM professionals today are longstanding, unrelenting, and—most importantly—multidimensional. Gender is intimately tied to other elements of identity—race and class, in particular—and the intersections of these elements complicate what it means to be a professional woman in STEM. The YWSTEAAM™ approach is concerned with addressing the social conditions and organizational climate necessary for underrepresented groups to persist and thrive in greater numbers in STEM careers.

Conventional wisdom leads us to believe that when women leave the workplace, it's most often to care for their families. But times are changing, conventional wisdom is losing the truth it never had, and in a 2009–12 survey of female engineers—past and present—only 25% of those who'd left engineering reported doing so for family reasons.[47]

In fact, highlighting family diverts attention from the more sinister reasons for which women leave STEM in general and engineering in particular. As one civil engineering graduate puts it,

> Women leave engineering due to lack of job satisfaction, lack of reliable female role models, inflexible work schedules, workplace discrimination, white Midwestern men syndrome, and glass ceiling issues.[48]



At the heart of these problems is workplace climate: Organizational culture and policies play an instrumental role in shaping not only whether diverse women enjoy their jobs, but also whether they persist in their careers.

Plenty of corporations—STEM and otherwise—have already launched initiatives to recruit and retain diverse women. The question, therefore, is why these initiatives haven't

47 Fouad, Nadya, Romila Singh, Mary E. Fitzpatrick, and Jane P. Liu. "Stemming the Tide: Why Women Leave Engineering." National Science Foundation. 2012. http://studyofwork.com/files/2011/03/NSF_Women-Full-Report-0314.pdf

48 Ibid.

produced long-term results. In Debra Meyerson and Joyce Fletcher's estimation, traditional approaches to solving inequity have been inequitable themselves. Meyerson and Fletcher's article on shattering the glass ceiling delineates the usual courses of action into three categories: assimilation, accommodation, and celebration.[49]

In all three cases, nothing is eliminated within the workplace itself. Assimilatory practices—like teaching assertive leadership—shifts the onus of change onto the individual. Accommodating practices—like family-friendly work schedules—fails to challenge a fundamental belief that balancing home and work is a woman's problem. Celebratory practices—like channeling women into human resources for their sensitivity—operates on the basis of assumed differences.

While these methods aren't necessarily ineffective, they're only stopgaps against deeper cultural patterns and organizational systems. To ensure that the workplace is truly and sustainably equitable, the link between equity and effectiveness must be clearly established at the level of everyday practices, through diagnosis, dialogue, and experimentation.[50] Here are some questions to keep in mind:

- How do people in this organization accomplish their work? What, if anything, gets in the way?
- Who succeeds in this organization? Who doesn't?
- How and when do we interact with one another? Who participates? Who doesn't?
- What kinds of work and work styles are valued in this organization? What kinds are invisible?
- What is expected of leaders in this company?
- What are the norms about time in this organization?
- What aspects of individual performance are discussed the most in evaluations?
- How is competence identified during hiring and performance evaluations?[51]

Equity Idea: Race and Gender Inclusive Practices

- Transparency and reporting on equity measures
- Explicit pathways to promotion, salary increases, etc.
- Formal mentoring
- Support networks
- Recognition

49 Meyerson, Debra E., and Joyce K. Fletcher. "A Modest Manifesto for Shattering the Glass Ceiling." Harvard Business Review 78, no. 1 (February 1, 2000): 126–36.

50 Ibid.

51 Ibid.

In addition to this abstract framework, University of Wisconsin–Milwaukee Educational Psychology professor Nadya Fouad and other researchers offer two crucial concrete recommendations: a zero-tolerance code of conduct and transparent paths for advancement.[52] Repercussions should be applied to employees who pass denigrating remarks, and data on salaries and promotions should be made public. Given that these solutions compel higher-ups to enforce them, they're well positioned to root out inequity where it's hardest to reach—in management—and to initiate top-down reform. Supplementary measures might include work-life flexibility, opportunities for formal and informal mentoring, and professional development, but Fouad et al. found, and stressed, that tangible changes demand cultural backing:

> While organizations' systems, policies, and actions mattered a great deal, the micro-climates at work, characterized by supervisors and co-workers who supported or undermined, also exercised a profound influence on women engineers' satisfaction, commitment and ultimately, their desire to leave the company and/or the profession.[53]

As workplaces tend to be hierarchical, this cultural backing can be set in motion—as mentioned above—with changes that hold supervisors responsible for implementing them.

It takes courage and patience to open up dialogue and negotiate with supervisors. And it takes time: The fight to unravel generations of toxic behavior will be long and sometimes regressive. But allowing such behavior to go unchecked—and thereby allowing the norm to go unquestioned—will only perpetuate the same obstacles that impede professional women in STEM today.

Shifting Culture

As we build programs to foster girls' interest in STEM, as we train teachers and employers to adopt gender-inclusive practices, as we hold conversations about concepts like gender equity and curricula, we must bear in mind that the lack of women in STEM is symptomatic of deeply entrenched cultural beliefs. The programs, the practices, the conversations—they must be precise and intentional.

52 Fouad, Nadya, Romila Singh, Mary E. Fitzpatrick, and Jane P. Liu. "Stemming the Tide: Why Women Leave Engineering." National Science Foundation. 2012. http://studyofwork.com/files/2011/03/NSF_Women-Full-Report-0314.pdf

53 Ibid.

Women will almost certainly fill the ranks of STEM education and careers. It's a matter of economic necessity. Consider that "women went from earning fewer than 10 percent of law and medicine degrees in 1970 to earning almost half of them by the early 2000s."[54] Although we might feel inclined to attribute this development to cultural progress, we can't ignore the "rising demand in formerly male-dominated industries" in the postwar era—an era in which many women's "cultural attitudes were upended by economic developments."[55]

But relying on economics to transform culture is not a sustainable approach. For one thing, the economy is erratic, and we have to ensure that women flourish in STEM at a constant rate. For another, when culture appears to change because of economics, it's not actually changing. If the STEM fields achieve gender parity only because there are more jobs than there are willing and able men, then we've done little but to construct a new veneer—to disguise compulsory economic actions as voluntary efforts at social progress. Women should feel empowered to study and work in STEM, regardless of supply and demand. This empowerment may begin with schools and workplaces, but as part of a larger cultural concern, it must simultaneously extend to other areas of life.

Home. In the home, researchers observe that boys and girls are socialized differently. From the everyday messages that parents send their children to the separation of toys by gender, the problem of inequity takes root early in life:

54 Cohen, Philip N. "How Can We Jump-Start the Struggle for Gender Equality?" The New York Times, November 23, 2013, sec. Opinion. http://opinionator.blogs.nytimes.com/2013/11/23/how-can-we-jump-start-the-struggle-for-gender-equality/

55 Ibid.

> Boys are encouraged to be more physically active while girls are encouraged to be affectionate and tender… The nature of the play experiences and toy choices of boys provides more opportunity for the development of spatial visualization and basic math and science skills than do the play experiences and toy choices of girls. Thus, boys tend to have an environmentally induced advantage in math and science even before they are introduced to these subjects in school.[56]

The problem grows once children enter school, as parents—consciously or not—reinforce gender binaries. Parents routinely underestimate daughters' talents in athletics and overestimate sons' talents, provide girls with more opportunities to read and interact socially with peers, provide boys with more opportunities for sports and computing, and attribute sons' versus daughters' academic successes and failures to different things.[57]

Though few and far between, some pioneers have set out to offset the effects of this sort of upbringing. Debbie Sterling, a Stanford engineer, created GoldieBlox to inspire girls to develop spatial skills along with an interest in engineering. The set of toys combines reading and building, which "appeals to girls because they aren't just interested in 'what' they're building...they want to know 'why.'"[58] Alice Brooks and Bettina Chen partnered to create Roominate, a dollhouse building kit designed with the belief that "every girl is an artist, architect, engineer, and visionary."[59] The slogan is reminiscent of STEAM—science, technology, engineering, art, and math—an acronym that has recently risen to prominence in STEM education. Expanding beyond toys, Carolyn Danckaert and Aaron Smith founded A Mighty Girl, an online curation of books, toys, music, and movies "that offer positive messages about girls and honor their diverse capabilities," including in math and science.[60]

These endeavors are pivotal. They immerse girls in STEM and add dimension—social

56 Tindall, Tiffany, and Burnette Hamil. "Gender Disparity in Science Education: The Causes, Consequences, and Solutions." Education 125, no. 2 (Winter 2004): 282–95.

57 Eccles, Jacquelynne. "Gendered Educational and Occupational Choices: Applying the Eccles et al. Model of Achievement-Related Choices." International Journal of Behavioral Development 35, no. 3 (1 May 2011): 195–201.

58 Sterling, Debbie. "GoldieBlox: The Engineering Toy for Girls." Kickstarter. 2012. Accessed 16 July 2014. https://www.kickstarter.com/projects/16029337/goldieblox-the-engineering-toy-for-girls

59 Brooks, Alice, and Bettina Chen. 2014. Accessed 16 July 2014. http://www.roominatetoy.com/

60 Danckaert, Caroly, and Aaron Smith. 2014. Accessed 16 July 2014. http://www.amightygirl.com/about

responsibility, artistry, and diversity—to what being in STEAM can include. The YW-STEAAM™ broadened approach that includes ***Activism***, signals the importance of both girls' personal agency and the accountability of educators, communities and policy makers to make widespread cultural shifts. And more than that, we need parents to support and interact with their children—boys and girls—in ways that don't attribute inherent qualities to gender. In short, shifting culture in the home is threefold. It requires (1) parents to recognize and reevaluate gendered treatment of their children; (2) innovators to develop entertainment for diverse girls that challenges narratives of passivity and princessdom; and (3) cultivating gender justice agency in girls engaged in STEM.

Equity Idea: Social Justice Awareness

- Actively use more inclusive social narratives
- Use STEM in the study of a social phenomenon
- Demystify STEM jargon and practices

Media and pop culture. Many gender equality leaders believe media outlets objectify and patronize women every day. It comes as no surprise then, that the relationship between pop culture and women in STEM vacillates between strained and nonexistent. After all, women in STEM commit a dual crime: They simultaneously flout the belief that they are agents rather than objects and trespass into territory dominated by men.

Thus, for the most part, female scientists and engineers are rendered invisible in the media. Whereas shows like *Ally McBeal* and *Grey's Anatomy* exist for aspiring lawyers and doctors, no such show caters to women and girls who long to become programmers or astrophysicists. And it's not that computer science and astrophysics receive no treatment in the media. The sitcom *Silicon Valley* chronicles the trials of six brogrammers, and The Elegant Universe's Brian Greene regularly expounds on the wonders of the universe on PBS. However, *Silicon Valley*'s brogrammers—acknowledge "the only female characters in the first two episodes are a lap dancer and a personal assistant"[61] —and Brian Greene—admits that he fits the image of "white male scientist" to a T—which makes women and girls feel less welcome in their respective fields.

When women in STEM receive screen time, they're pigeonholed and distorted. An analysis of primetime programs aired from February 6 to March 4, 2012, showed that only

61 Gilbert, Gerard. "Why new TV show Silicon Valley is like Entourage for geeks." The Independent 15 July 2014. Accessed 16 July 2014. http://www.independent.co.uk/arts-entertainment/tv/features/silicon-valley-entourage-for-geeks-9605916.html

21.1% of characters with STEM careers were women.[62] The situation is even bleaker for family films theatrically released between 2006 and 2011: Women made up a mere 16.3% of characters with STEM careers, four of whom worked in engineering or computer science, as compared to 57 male actors.[63] Meanwhile, "there is no shortage...of female teachers, nurses/social workers/therapists, or administrative assistants."[64]

Numbers aside, the on-screen depictions display troubling attitudes towards women in STEM, at least in the United States. Writer Eileen Pollack inveighs against the American sitcom The Big Bang Theory for flagrantly misrepresenting its female characters:

> Although two of the scientists on the show are women, one, Bernadette, speaks in a voice so shrill it could shatter a test tube. When she was working her way toward a Ph.D. in microbiology, rather than working in a lab, as any real doctoral student would do, she waitressed with Penny. Mayim Bialik, the actress who plays Amy...really does have a Ph.D. in neuroscience and is no way the hideously dumpy woman she is presented as on the show.[65]

On the other hand, Penny—hopeful Hollywood star and neighbor to the show's male protagonists—is "stylish" and "bouncy," thereby feeding into the notion that these qualities elude women who pursue traditionally masculine fields.[66]

The influence of media and pop culture cannot be overstated, because the messages we receive have a real and lasting impact on what we believe and how we perform. To explore this phenomenon, a 1999 study at the University of Michigan administered a math test to two groups of students with similar abilities. The first group was told that men perform better on math tests than women, while the second was assured that there is no difference between male and female performance. The men ended up outscoring the women by 20 points in the first group but by only 2 points in the second.[67]

What does this mean for us in terms of next steps? First, we need to recognize and

62 Smith et al. "Gender Roles and Occupations: A Look at Character Attributes and Job-Related Aspirations in Film and Television."

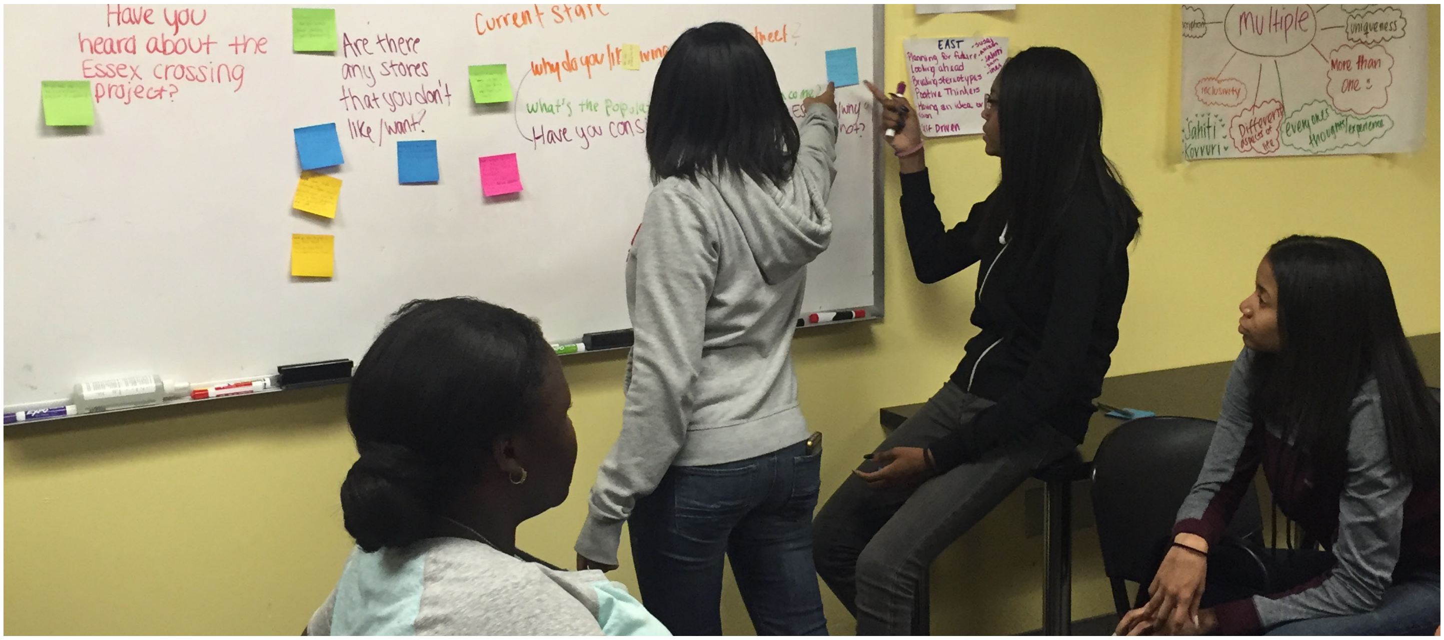
63 Ibid.

64 Ibid.

65 Pollack, Eileen. "Why Are There Still So Few Women in Science?" The New York Times, October 3, 2013, sec. Magazine.

66 Ibid.

67 Ibid.



celebrate the efforts of diverse women in STEM. Time and again, women are overshadowed by the men alongside whom they work. Notable examples include Emily Warren Roebling, who headed construction of the Brooklyn Bridge after her husband passed away, and Rosalind Franklin, who snapped the images of DNA that Watson and Crick would later use to propel themselves to fame. Worse yet, women of color are virtually absent from the limelight, as they "have been, and continue to be, stuck at junior-level positions, not advancing to leadership positions" where they can earn recognition "at the same pace as their male and white female counterparts."[68] The early and ongoing contributions to STEM by women of color are overshadowed by more favored narratives about their contributions to the arts and humanities. The net affect has created a gulf between women of colors' actual contributions to STEM and girls of colors' access to a wider range of possibility models. We must strive to create more platforms that display women in STEM across race, age, disciplines, and temperament.

Equity Idea: Race and Gender Inclusive Practices

- Normalize the presence of women in STEM
- Amplify underrepresented women's contributions in STEM

---

68 Ong, Maria. "The Mini-Symposium on Women of Color in Science, Technology, Engineering, and Mathematics (STEM): A Summary of Events, Findings, and Suggestions." National Science Foundation. 2009. http://www.nsf.gov/od/iia/activities/ceose/reports/TERC_mini_symp_rprt_hires.pdf

Conclusion

Ainissa Ramirez, Yale University Materials Science Professor reminds us that "STEM is the future. And the future belongs to everyone." Engineers and scientists build and create our future, but will women have an equal voice and role in constructing what our future will look like? With evidence from research and successful initiatives by pioneering schools and nonprofits, we have identified the problems and we know what the solutions are, too. Through careful reflection and dialogue, STEM equity advocates can transform cultural narratives about women and girls in STEM. Perhaps more importantly, those advocates can demand the integration of equity strategies in STEM settings that will lead to gender parity. The YWSTEAAM™ approach encourages use of well-researched pedagogical strategies, while inviting women and girls and institutions to become more active within their classrooms, labs and workplaces to insist on gender equity. As G.J. Campbell has observed, the failure to solve STEM's attrition problem stems from an overemphasis on the deficiencies of female students (or students of color), and "under emphasis on institutional deficiencies."[69] Resolving the gender- and race-based inequity in STEM is a matter of mustering the will to reform the system and transform our culture. Closing the gender gap in STEM is a matter of social justice

69 Espinosa, Lorelle L. "Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence." Harvard Educational Review, 2011. p. 215.

Appendix

Research Experts Reflections

Researchers of late have devoted extensive attention to STEM education. This burst of interest comes as no surprise: Given present trends, the U.S. will need a STEM workforce of 8.65 million people by 2018. As the date approaches, researchers are taking special care to look at a huge but oft-ignored demographic: women.

Although women nationwide earn 60% of bachelor's degrees, only 40% of STEM degrees belong to women, and of those, even fewer are in physics, computing, or engineering. Simultaneously, girls are expressing more and more interest in STEM as well as outperforming boys in STEM classes before college.

What, then, accounts for this tension? Why do women and girls gradually but surely pull away from STEM? Which factors cause them to leave, and which ones induce them to stay? Here's what we took away from interviewing our six research experts.

BIG PICTURE

Work in STEM fields can be laden with details—formulas, calculations, precise dimensions, and inflexible deadlines—all of which crowd out the big picture from time to time. This phenomenon affects men, too, but it exacts an especially harsh penalty on women because of (1) the lack of female role models in STEM and (2) the cultural imposition of implicit bias.

To ensure that women thrive in STEM education, we need to start thinking about when and why women can't see the big picture—and what we can do to dismantle the structures obscuring their vision.

Leadership. Dr. Jacquelynne Eccles, an education professor at UC Irvine, asks STEM advocates to consider a big-picture consideration: hardly any women in STEM hold positions of influence. In fact, coveted careers as tenured STEM professors, research lab directors, and engineering project managers are overwhelmingly male. This means that when women and girls try to project where they'll be in ten years—to see the big picture behind their efforts—their imagination plateaus. To combat this toxic trend, we might consider a number of inclusive practices.

- **Outreach programs** (being leaders): Engaging people of all ages in the community can be a great way to remind students of the relevance of STEM and to expand their sense of possibility for what careers in STEM can look like. For example, astronomy through problem sets might come off as dry and distant, but if students organize and lead a stargazing event at school, they'll nurture their conception of astronomy in ways that aren't as easily accomplished in the classroom.
- **Near-peer mentorship** (being leaders, seeing leaders in the short term): A program where younger students can learn from older students would benefit both parties. Not only would the younger students have the opportunity to connect with immediate role models, but the older students would also build a stronger commitment to their work. As it pertains to college campuses, Colorado College physics professor Dr. Barbara Whitten suggests having students doing all sorts of inclusivity work—leading tutorial programs, holding picnics, and teaching seminars. To sustain this model, faculty can be trained to supervise mentorship and inform incoming classes of its availability.
- **Recruitment of female faculty** (seeing leaders in the long term): The person delivering a lesson is as important as the content of the lesson itself. When female students regularly come in contact with female STEM instructors, those students get the message—however subtly or unconsciously—that they're welcome in STEM. High schools and colleges should make an active effort to recruit female teachers and professors, particularly those with substantial bodies of research, as they're well positioned to model for and mentor women and girls.
- **Self-directed projects** (being leaders): Students have different reasons for pursuing their fields of study. In STEM, though, more so than in the humanities, these reasons can be drowned out by rigid curricula, which provide no room for leadership or experimentation. To engage as many students as possible, as early on as possible, introductory classes should bridge the gap between textbook content and practical applications by allowing students to take on projects relevant to their own lives.

Implicit bias. Professors encourage more male than female students to pursue research and graduate study in STEM, regardless of class performance. Examples in physics textbooks rely almost exclusively on mechanical objects, even though teaching physics concepts through biological and chemical processes has been shown to produce better outcomes for female students. Many women and girls who do poorly in STEM classes report believing that their grades reflect innate ability—no doubt a result of stereotype threat. Dr. Nadya Fouad explains, these events all warp the big picture for women in STEM, and worse yet, they're far from being isolated. Rather, they point to implicit bias, or the attitudes that people unconsciously internalize and draw on when making decisions. Although implicit bias has its roots deep in our cultural fabric, we can take some first steps to raise awareness and initiate reform.

- Zero-tolerance climate (psychological environment): On an individual level, a zero-tolerance climate operates by a familiar mantra: "If you see something, say something." Peers must go beyond recognizing problematic behavior. They must call it out, through sensitive but firm discussion. On an institutional level, schools should strive first to be explicit—perhaps by compelling students to sign a code of conduct—and then to be transparent—by implementing policies that outline clear repercussions for violators.

- Welcoming spaces (physical environment): Yale biology professor and White House education policy consultant Dr. Jo Handelsman emphasizes how small changes to a classroom can produce measurable differences in girls' interest in STEM. Adding odd, neutral objects like a phone book or a plant—as opposed to a poster filled with digits and formulas—makes the experience of learning new things less intimidating. Schools can expand on the idea of a safe space by providing student lounges that cater to particular demographics—say, physics students or women of color in STEM—and thereby foster self-identification and camaraderie.

- Teacher training (psychological environment): Mandating workshops for STEM instructors will help to bring implicit bias to the forefront of their minds, and reduce the frequency with which it manifests itself in the classroom. Useful topics to touch on range from stereotype threat and growth mindset to body language and gender-neutral practices.

- Visible role models (physical environment): Books, films, and other media need to start displaying more women in STEM—of all disciplines, of all ages, of all races, and of all other dimensions of identity. While schools can't sway the entertainment industry overnight, they could stand to be more cognizant of image. Whose research is being displayed at orientation? Which STEM instructors have been chosen for this panel discussion, and has anyone—or have any groups of people—been inadvertently excluded? This is a call not for false advertising but for critical analysis of who receives recognition, who doesn't, and why this discrepancy exists.

- Flipped classroom model (psychological environment): Dr. Jenny Vazquez-Akim—the Director for Student Engagement and Career Connections at University of Southern California—encourages us to reconsider whether lecture is the most fruitful way of learning. In her experience, group work is vastly preferable because it ushers diverse voices into usually monotonous technical conversations. As such, she's a big advocate for the flipped classroom model, in which students watch prerecorded lectures on their own time and come to class to collaborate on assignments with professors and other students.

Practitioners' Insight

A myriad of extracurricular programs have been developed to launch K–12 girls into STEM. As we learned, these programs usually converge on technology and engineering, where female representation—even compared to that in science and math—is egregiously low. Here are some other insights we gleaned from our conversations with four program directors.

COMMUNITY

When designing programs to engage girls in STEM, we thought that curriculum would be the main element of concern. But Ruthe Farmer, the Chief Strategy and Growth Officer of the National Center for Women and Information Technology, asserts to the contrary that community should take precedence—an assertion with which our other interviewees unanimously concurred.

- **Single-gender space**: Program directors can mitigate implicit bias by having girls interact only with other girls. Preventing implicit bias from entering the picture—in other words, leaving out boys and the unconscious baggage that their presence brings to a space—positions girls to learn and grow free from the influence of gendered group dynamics.

- **Near-peer instructors**: Instructors culled from the high school and college level are ideal for the same reason that near-peer mentors are so effective. They give girls an immediate sense of who they can become, and they're also vastly more cost-effective than traditional instructors. AspireIT, for instance, a program that issues grants to undergraduate women in computer science to teach girls how to code.

- **Collaborative environment**: It's a given that girls should learn to work together on projects, but it's also important for them to present what they've done as a group and to be celebrated for their efforts, which results in higher self-efficacy. Furthermore, program directors should try to build networks for girls in STEM to stay connected outside of the program, via a pen-pal system or an online forum in addition to periodic conferences and gatherings. Such networks counteract the stigma of geekiness associated with STEM, moving girls to understand that there is no real social cost to loving science.

ACTIVE LEARNING

Part of STEM fields' negative reputation is their approach to learning: sitting in lectures, memorizing formulas, and regurgitating them on exams. Naturally, then, active learning is a top priority, and as girls face unique challenges in this area, we must consider unique channels of engaging them.

- **Hands-on activities**: The distribution of work during group projects is rarely ever equal. As noted before, boys disproportionately conceptualize and assemble the products, while girls were left to take on more secretarial roles, like taking notes and presenting what they'd accomplished. Thus, program directors should design projects explicitly requiring all team members to rotate through different roles so that everyone has a chance to lead.
- **Critical thinking**: Instead of emphasizing the peculiarities of individual programming languages. Any good STEM programs, should aim to develop transferrable skills like understanding systems and concepts.
- **Failure**: A director at a leading girls STEM organization reminds students that failure is a natural part of the learning process. This reminder doesn't just happen verbally, but by incorporating failure into the curriculum helps to generate confidence and drive home the message that STEM is as much about the process as it is about the answer.

CAREER EDUCATION

In 2012, the Girl Scout Research Institute conducted a study on girls and STEM, and found that the girls who expressed the most interest in STEM had a clear idea of where it could take them in the future. Likewise, all practitioners described at length the fruits of career education for their participants.

- **Speakers and panels**: Bringing in inspirational speakers or organizing panels of young women in STEM not only exposes girls to potential mentors but also enables them to ask questions—to be curious—about what they can do in the future. Additionally, leave time for networking amongst attendees.

- **Diversity**: Broadening girls' conception of what it means to work in STEM is as simple as taking field trips to local companies, drawing attention to the social applications of group projects, or, as mentioned above, hosting speakers from various disciplines. When girls perceive STEM to be more flexible than sitting all day in a cubicle—a distorted image that the media has trumpeted incessantly—they're more likely to feel like it fits in with their life goals.

- **Partnerships**: Education nonprofits and tech giants alike can serve as essential partners to an extracurricular STEM program. With their support, program directors have access to more resources—more role models, more spaces, more publicity. These resources can then be leveraged to offer more opportunities to girls without the burden of creating new infrastructure.

Teaching Tips from Jeffry Mallow's Science Anxiety: Research and Action

We hope that our instructors strive to serve our students in gender-inclusive ways, create safe spaces where they can discover a love for STEM, and support students in developing science identity and building self-efficacy. These strategies are not instructions for how you should run your classroom, but some helpful tips for assessing how you interact with students and structure lessons.

1. **Explicit science skills teaching**. Frequently, students have been taught only the skill of memorization, which is not effective in understanding science. Instructors should clarify how to read science differently from history or literature, organize and solve word problems, take notes in science classes, perform science laboratories, and take quizzes and examinations. Instructors should also convey the importance of asking questions, and can consider incentivizing question-asking. On the first day, instructors should explicitly describe his/her question-asking policy, so as to eliminate any uncertainty about when it is appropriate to ask questions and what types of questions are appropriate.

2. **Group work**. Group work enhances student performance and improves rates of persistence in the STEM fields. Students report that they prefer group projects to traditional lectures because of the interactive, cooperative components and the control of individual competition. If working with a group that is shy or hesitant to speak up, teachers can use "Think Pair Share," or the practice of having students discuss their ideas with a partner before sharing in front of the entire class. This exercise of discussing first with a partner alleviates anxiety and gives students a chance to organize their thoughts.

3. **Theme-based curricula**. Drawing students into science through themes is an effective way of providing them with a comfortable classroom environment. To do this in a whole course may be a fairly radical departure from the norm. It has, however, been successfully applied elsewhere. It can in any case be introduced as one element of a course.

4. **Attention to wait time and equity in calling on students**. When instructors pause frequently during lecture, students absorb significantly more information. Furthermore, when asking questions, instructors should give at least 20 seconds for stu-

dents to formulate their thoughts and should try to distribute the questions equally among students. Keeping a written record of which students have been called on is very helpful.

5. **"Catch students doing something right!"** Instead of immediately calling on someone else when a student is struggling with a question, instructors should stay with the student who has been questioned, work backward through Socratic dialogue until that student reaches the last concept that she understood, and then move forward to eliciting the right answer.

6. **Balancing content and relationship in teacher-student interactions**. Teachers interact with students in four major ways:
   - the classroom learning environment,
   - information transfer between teacher and student,
   - teacher-student interaction, and
   - teachers' evaluations of student performance.

   The learning environment includes body language, tone of voice, word selection, and classroom organization by the teacher. Information transfer deals with all aspects of content, from course ground rules to teaching techniques, and how these can affect student confidence. Teacher-student interaction focuses primarily on the technique known as active listening, helping teachers modify their listening styles so that they hear the student's whole agenda, not simply the one he or she presents. Even such subtle but critical items as placement of chairs in the teacher's office are important. Finally, evaluation of student performance deals not only with fair and effective grading but also with the nature of comments on papers and tests and how these comments can diminish or enhance student confidence.

   To make interactions with students as meaningful as possible, instructors should strive to strike a balance between discussing STEM content and connecting with the student on a personal level. College students praise humanities and social science students who actively try to connect with students as individuals, asking them where they're from, what they're interested in, and what they aspire to do. STEM instructors should aim to achieve these personal connections with students, while maintaining a professional balance with the actual science content.

7. **Explicit focus on metacognition**. Effective learning is highly correlated with the

use of metacognitive or self-regulatory skills. Monitoring “how we learn what we learn”—for instance, by breaking down the scientific method and related modes of inquiry—can lower students’ anxieties in the classroom while providing a unique way for students to process the material they are learning. This “stepping back” helps demystify the learning of science and undercuts the myth that there is a special, rare, and unteachable talent needed for doing so.

8. **Response to the wide variety of student learning styles**. This practice encompasses many of the other recommendations. The more multimodal the classroom—lecture, demonstrations, group work, brief writing exercises, Socratic dialogue—the more students will be engaged and the less estranged and fearful they will be.

9. **Implicit bias**. Implicit bias refers to the unconscious attitudes that we internalize and reflect in our interactions with other people. As with accommodating different learning styles, the project of limiting implicit bias includes many of the aforementioned recommendations—highlighting science skills, distributing questions equitably, and balancing content and relationship. In addition to taking these steps, instructors should pay attention to (1) the types of examples they draw on as well as (2) their code of conduct in the classroom. On the first point: Consider that examples in physics textbooks rely almost exclusively on mechanical objects, even though teaching physics concepts through biological and chemical processes has been shown to produce better outcomes for female students. On the second point: Creating—and having students agree to—a zero-tolerance code of conduct can raise awareness of and thereby mitigate implicit bias.

10. **Provide frequent feedback and verbalize expectations**. After recognizing the possibility of personal bias, teachers can evaluate how they interact with female students and work toward ensuring that they teach in gender-inclusive ways. Research shows that teachers tend to interact more often and in more detail with boys than with girls, asking males more detailed questions that call for higher-order thinking, offering them more feedback, and giving them more valuable and specific comments. Teachers also tend to exhibit higher expectations for boys and encourage them more to engage in problem-solving activities. By the time they reach college, boys are twice as likely as girls to initiate comments and have received 1,800 more hours of attention and instruction than girls. Moreover, due to stereotype threat and social cognitive factors, girls tend to have lower expectations for themselves than boys do, and thus need more encouragement than boys. Thus, instructors play a critical role in prais-

ing students and verbalizing expectations to foster girls' self-confidence. Instructors should feedback in a specific, encouraging, and timely manner to students, praising them for the steps they take in the process of solving a problem, not for success at the end of the project. For example, "You're so smart!" conveys to students that they succeed through innate ability, whereas "You've completed [this task] diligently and patiently" rewards students for their effort and persistence. On the other end of the spectrum, instructors should avoid indiscriminately praising students for "good effort" when they have not exerted effort or approached the problem with a negative attitude.

Adapted from Jeffry Mallow's "Science Anxiety: Research and Action," the first chapter in the 2006 Handbook of College Science Teaching. Citation:

Mallow, Jeffry V. "Science Anxiety: Research and Action." Handbook of College Science Teaching. Ed. Joel J. Mintzes and William H. Leonard. Arlington, VA: NSTA, 2006. 3-14. Print.

Online Resources

The following are some online resources to support learning: equity tools, projects, videos and apps, and curriculum ideas .

EQUITY TOOLS

Racial Equity Tools: http://www.racialequitytools.org/home
NCWIT: https://www.ncwit.org
Project Implicit: https://implicit.harvard.edu/implicit/takeatest.html

PROJECTS

IDEAS by ASME

https://www.asme.org/career-education/k-12-students/integrated-design-engineering-activity-series

The Integrated Design Engineering Activity Series (IDEAS) provides 10 hands on, low-cost engineering projects for middle school students, with a focus on civil and mechanical engineering. Each project provides objectives and instructions for 3 different levels of activity—exploratory, intermediate, advanced—so students can work in stages, from basic investigation to actual construction. The projects incorporate verbal skills as well, with research and writing tasks in addition to the design and engineering components. Projects include…

- Alternative Energy: Wind Powered Machines
- Amusement Parks and Playground Physics
- Sanitation Systems
- Geodesic Domes and Sheltering Structures
- Historical Catapults
- Solar Collector
- Investigating Isaac's Ideas
- Toothpick Bridges and Other Structures
- Buoyant Vehicles
- Slow Roller and Friction Experiments

Science Buddies
http://www.sciencebuddies.org/

A compilation of information about dozens of STEM careers and related project ideas. Careers include…

- Computer programmer
- Biochemical engineer
- Marine architect
- Robotics technician
- Aviation inspector
- Power plant operator
- Biofuel technology and development manager
- Climate change analyst
- Pilot
- Commercial and industrial designer

SciGirls by PBS
http://scigirlsconnect.org/page/activities

A collection of hands-on projects, teaching guides, and lesson plans for middle school girls (age 8 to 13) to accompany the PBS "SciGirls" TV series. There are seven series, with 5 activities each:

SciGirls Explore: The Science of Living Things
- Multitasking Mania (experiment to test the effects of multitasking)
- Color Code (test the Stroop effect)
- Plants Count (explore and survey a natural habitat)
- Breaking Point (build a penetrometer to test plant toughness)
- Workin' it Out (experiment with exercise's effect on heart rate)

SciGirls Investigate: Physical Science Fun!
- No Slip Grip (test for friction on different surfaces)
- Insulation Station (design and test insulation device for ice)
- House Warming (build houses to test sun's effect on different designs)
- Super Sleuths (trace the evidence to solve the mystery)
- Print Hints (design a way to use shoe prints to solve a crime)

SciGirls Invent: Engineer Your World
- The Awesome Game Race (design your own game)
- Pedal Power (bike gears)
- Crank It Up (create your own gears and moving sculpture)
- Grab and Go (build a mechanical lifting arm)

- Deep Sea Diver (design a deep sea diver)

SciGirls Engineer It

- Bouncing Balloons (engineer a super bouncy ball)
- Parachute Parade (build a parachute for a toy figurine)
- Twirling in the Breeze (build a device that spins in front of a fan)
- Puppet Power (build a shadow puppet with moving parts)
- Blowin' in the Wind (build a windmill that lifts weight)

SciGirls Live Healthy

- This Bitter Be Good (test how the bitter compound PTC influences taste)
- Breathing Room (test the size of the balloon hole and breathing capacity)
- Take it in Stride (design a method to measure stride length)
- Science Cooks (create a healthy version of a granola bar)
- Heart to Heart (build a stethoscope and test exercise and heart rate)

SciGirls Get Tech

- Robot Body Language (express feelings using body movements)
- Passion for Pixels (transmit an image digitally)
- Dough Creatures (use dough to make battery-powered creatures)
- High Tech Fashion (make a fashion accessory that lights up with LEDs)
- Keep Out (build a room alarm that sounds when someone steps on it)

SciGirls Go Green

- Sink or Swim (test different types of plastic)
- Light Bulb Challenge (test the energy efficiency of different light bulbs)
- Going Green (conduct a waste audit and implement a plan for reducing trash)
- Star Power (build a constellation box and design a shield for light pollution)

Design Squad Nation by PBS
http://pbskids.org/designsquad/parentseducators/index.html

A collection of engineering education resources, including lesson plans, teaching guides, projects, and videos, that go along with episodes from the PBS show "Design Squad Nation." In addition to an Educator's Guide and Event Guide, the teaching guides include…

- Mission Solar System (six space challenges, grades 4-8)
- Teacher's Guide for middle school STEM classrooms
- Invent it, Build it (activities that focus on invention)
- On the Moon (space activities, grades 3-12
- Activity Guide for after-school programs

Projects are available for electricity, energy, health, environment, music, space, sports, and technology, including…

- Electric Highway
- Glow Sticks
- 4-Wheel Balloon Car
- Confetti Launcher
- Build a Better Lunchbox
- Solar Collector
- Sky Glider Blimp
- Soft Landing Airbag

VIDEOS AND APPS

MIT+K12
http://k12videos.mit.edu/

A collection of 30+ interactive (and funny) video lessons exploring the science of cool technologies for middle school students, created and narrated by MIT undergraduates. Lessons include…

- The Physics of Invisibility Cloaks
- Humanoid Robot Brains
- How to Discover a Planet
- Engineering Engines
- Growing Nanotube Forests
- The Science of Bouncing
- Sports Car Aerodynamics
- The Invention of the Battery
- How Information Travels Wirelessly
- Squid Skin with a Mind of Its Own

TED.Ed
http://ed.ted.com/

A database of 82,000 animated and interactive videos accompanied by lesson plans designed for classroom use, with categories such as Design, Engineering and Technology; Mathematics; Psychology; Science and Technology; Thinking and Learning. Some of the series (which include 5-30 related several video lesson plans) include…

- Superhero Science
- Inventions that Shape History
- Math in Real Life
- Actions and Reactions
- Troubleshooting the World
- Mind Matters
- Out of this World
- How Things Work
- Visualizing Data
- Awesome Nature

The Design, Engineering, and Technology lesson plans include…

- Under the hood: the chemistry of cars
- What is the World Wide Web?
- Making a car for blind drivers
- Pixar: the math behind the movies
- The shape-shifting future of the mobile phone
- Visualizing the world's Twitter data

The Science and Technology lesson plans include…

- Cell vs. virus: A battle for health
- A 3D Atlas of the Universe
- How do cancer cells behave differently than normal cells?
- From DNA to Silly Putty, the diverse world of polymers
- How does your brain respond to pain?
- The chemistry of cookies

Apps for Teaching STEAM
http://www.weareteachers.com/community/blogs/weareteachersblog/blog-wat/2013/06/26/60-apps-for-teaching-steam

A collection of 60 tablet apps for teaching STEM, integrated with art, divided by grade level (K-2, 3-5, 6-8, 9-12), including…

- Pocket Universe: Virtual Sky Astronomy
- TinkerBox HD
- Engineering Pro
- MoMA Art Lab
- Mathtopia+
- iEditor

CURRICULUM

PBS Learning Media
http://www.pbslearningmedia.org/

A repository of 7,000+ videos, audio clips, articles, images, lesson plans, and media galleries relating to math and science, among many other subjects. Suited for students K–13+. Selections cover a vast array of topics, including…

- LEGO Robots
- Hoover Dam and Hydroelectric Power
- Designing a Wheelchair for Rugby
- Acid Mine Drainage Remediation
- The Botany of Desire
- Early Evolution of the Human Hand
- Collisions on an Air Track
- Energy in a Roller Coaster Ride
- Careers in Science
- Navajo Elders' Observations on Climate Change

NSF Graduate STEM Fellows in K–12 STEM Education
http://www.gk12.org/resources/stem-activities-and-resources-for-k-12-teachers-and-students/

A directory of online resources organized by grade level (elementary, middle, and high school). Comprises lesson plans, projects, and other interactive materials sponsored by the National Science Foundation. Featured resources include…

- Science Update, a daily, 60-second radio show covering recent discoveries in science, technology, and medicine
- The Secret Lives of Wild Animals, a website that hosts videos from the animal's viewpoint
- Treasures in the Sea, a resource book to provide teachers of students in grades 3–6 with hands-on activities relating to marine conservation