Schools and Closing the Gender Gap Related to STEM

> Women have made tremendous progress in education and the workplace during the past 50 years. Even in historically male fields such as business, law, and medicine, women have made impressive gains. In scientific areas, however, women's educational gains have been less dramatic, and their progress in the workplace still slower…. By supporting the development of girls' confidence in their ability to learn math and science, we help motivate interest in these fields. Women's educational progress should be celebrated, yet more work is needed to ensure that women and girls have full access to educational and employment opportunities in science, technology, engineering, and mathematics.
>
> Garfein and Hallman (2010)

This resource focuses on (1) the problems females face related to the fields of science, technology, engineering, and mathematics (STEM), and (2) what can be done within the education system to improve the situation. The following questions are addressed:

- Why do females shy away from STEM?
- What is and isn't being done to address this problem at the K-12 level?
- What specifically can be done to attract African-American and Hispanic girls?

Why do females shy away from STEM?

Landivar (2013) reports that women hold only one-quarter of the jobs in STEM fields in the US, despite being about 50% of the population. Relatedly, they earn a disproportionately low proportion of bachelor degrees in computer sciences (18%), engineering (19%), and physics (19%).

Even in STEM fields, such as biology, where women earn an equal share or the majority of college degrees, they tend not to go directly into STEM jobs. Rather, they pursue careers in healthcare, education, or science-adjacent fields. It also is noteworthy that only 10% of STEM jobs are held by Hispanics, African-Americans, or Native Americans, and again only a small percentage of these are women.

Contrast this with survey findings indicating that 74% of teenage girls report being at least "somewhat interested" in one or more STEM fields (Modi, Salmond, & Schoenberg, 2012). (The investigators speculate that the interest among younger children may be greater.) Interest in a field, of course, is not tantamount to interest in a career; the same study reports that only 13% of those indicating interest also listed a STEM career as their top choice.

For many, gender gap findings reflect a problem that begins in childhood and worsens with age. A common explanation is that girls lose confidence in their math and science abilities due to early experiences and socialization that promotes sexist stereotypes about females' lack of ability in those subjects. Examples: Girls as young as six years old have been found to rate their math ability lower than boys, even when no actual difference in ability exists. They are also more likely to draw a man than a woman when asked to draw a scientist or someone who is good at math or science. There is evidence that loss of confidence and poor self-perceptions of math ability are significantly associated with poor performance and a decline in achievement equivalent to one year of school (OECD, 2015; Petersen & Hyde, 2015).

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Another line of psychological research focuses on the construct *stereotype threat* (Flore & Wicherts, 2015). In general, this research supports the idea that awareness of negative stereotypes about one's group can cause one to conform to the stereotypes. While the research on children and adolescents is limited and has been criticized for publication bias, it does seem likely that there is a negative affect on math and science performance for girls who believe the stereotype that all girls are bad at math and science. Just asking female students to indicate their gender before taking a test has been reported to have a negative impact on their scores (Corbett, Hill, & St. Rose, 2010). In addition, those girls who are pressured to meet high expectations may lose their motivation for a course if they are not doing well.

Other stereotypes also may have a negative impact on female performance. For example, girls are often expected to be passive and quiet; boys are encouraged to express their views. This may cause girls to feel uncomfortable participating in class, especially if the majority of the students are boys.

Stereotypes also can affect teaching. For example, some teachers may unintentionally pass on to students their own internalized stereotypes about females' science and math abilities (Beilock, Gunderson, Ramirez, & Levine, 2009). In contrast, highly competent female math and science teachers can provide positive models that may help counter stereotypes.

What is and isn't being done to address this problem at the K-12 level?

Most young children show some interest in what is encompassed by STEM. So, the challenge is how to build on existing interests of all and bolster intrinsic motivation as students get older.

Challenging Stereotypes and Sexism

As noted, some girls lose interest in STEM-related learning because of internalized gender stereotypes. Some are deterred from pursuing STEM careers because they are aware of sexism within those fields; 57% of all girls are reported as feeling that if they went into a STEM career, it would be harder for them to be taken seriously than it would be for a man (Modi, et al., 2012).

As a major societal force, schools try to combat stereotypes, gender and racial bias, and negative socialization practices. Increasing attention also is given to changing the culture of schools to ensure that effective responses are made when there is discrimination and harassment. All this, of course, remains a challenging agenda.

Focus on Teachers

There is evidence that teachers pass their own anxieties about math and science to students. This is especially a concern at the elementary level where there is too little preparation in specific subject areas. Currently, enhanced teacher education is viewed as a step in solving this problem. And, over time, gender stereotyping and other biases should be lessened as a new generation of teachers reflects societal changes related to socialization of the young.

One emphasis in teacher education is on ways to build girls' STEM-related motivation and capabilities. This involves personalizing instruction and, if needed, providing special assistance (Adelman & Taylor, 2006; Center for Mental Health in Schools, 2014). It requires a daily focus on maximizing feelings of self-determination, competence, and connectedness to significant others and minimizing threats to such feelings (Deci, 2009; Ryan & Deci, 2009).

Another emphasis is to move away from science education that mostly involves memorizing facts and formulas, providing detailed steps to follow in doing experiments, telling students what results are expected, and then grading those results. Many students don't like this method for learning, and are poorly motivated by it. This contrasts with instructional approaches that approach the scientific process as a trial and error process from which a considerable amount can be learned even when an experiment "fails".

Some Teacher Do's and Don'ts

There is a burgeoning literature on understanding how to enhance and avoid turning off the interest of female students in STEM fields (e.g., Halpern, et al., 2007; Modi, et al., 2012; Wiest, 2014). This literature includes recommendations for teachers. For example, it is important to build on interests, and 92% of girls who report an interest in STEM say they are motivated by wanting to make a difference in the world. (There is some evidence that this may be a stronger motivator for girls than for boys.) Given this, teachers can stress the many different ways in which STEM makes the world a better place. They also can demonstrate that STEM knowledge and skills is useful in many fields not directly related to science or math. For example, computer skills can be incorporated into various subject areas, including ones in which girls are especially interested in performing well.

The literature also emphasizes the importance of instruction that conveys that ability and intelligence are not fixed qualities, encourages perseverance, and counters the idea that an entire gender can be inherently bad at certain academic subjects. In this context, good practice involves not praising students by referring to innate talent, but rather providing positive feedback about perseverence, progress, and plans for next accomplishments. Good practice also involves avoiding direct comparisons of girls and boys as groups and pitting them against each other (e.g., trying to make girls feel better by praising them with statements such as "she's even better than the boys").

Also, teachers are advised to take care in grouping students, calling on them in class discussions, and providing feedback. For example, there is concern that, when only one or two girls are placed in a majority boys group for collaborative projects, the boys are likely to dominate the process. When calling on students, equal time for girls and boys is important. And, when students are stuck, feedback, guidance, and support needs to be directed at helping them work through the problem rather than providing the solution.

See Appendix A for the recommendations in the What Works Clearinghouse guide.

Connect Students with Role Models

Inviting women who have been successful in STEM fields to speak to or lead activities with students provides role models and can help counter stereotypes. It also enables the class to learn from someone who can talk about the field, its opportunities, and its contributions from a personal perspective and with direct application to female experiences.

A cadre of female mentors also can be recruited to form one-on-one connections. These role models can be recruited from a variety of sources, such as college students, retired professionals, museum staff, professionals working in STEM fields, science teachers, etc. (Goodman & Damour, 2011).

School aside, girls interested in STEM fields report having parents who are interested in these fields themselves and encourage their daughters to pursue such careers. They also report that other important people in their lives support such interests (Modi, et al., 2012).

Enhance STEM Enrichment Opportunities and Career Visibility

Enrichment opportunities are important ways to enhance interest and skills outside the classroom and beyond mandated curriculum. For example, libraries, science museums and exploratoriums, science fairs, and the internet provide places where students can learn more about the STEM-related topics that interest them and do so in the ways that fit their motivation, capabilities, and learning styles.

STEM-oriented clubs at school and in the community also can enhance visibility and interest in the topics and career possibilities. Job shadowing and internships provide even lengthier contacts with role models and more intensive direct experiences.

What specifically can be done to attract African-American and Hispanic girls?

According to a 2013 report from the U.S. Census Bureau, African Americans make up 11 percent of the U.S. workforce but only 6 percent of STEM workers. Hispanics make up 15 percent of the U.S. workforce, but just 7 percent of the STEM workforce.

Available data suggest that African-American and Hispanic girls show slightly more interest in some aspects of STEM than white girls, and 41% of African-American girls and 31% of Hispanic girls say they would choose a high-paying career over one they really enjoyed. At the same time, they are less likely to know someone in a STEM career or to receive help from their parents regarding career choices. They also report that their parents and teachers are less supportive of their interest in STEM (Modi, et al., 2012). Moreover, as they get older, they learn about institutionalized racism, sexism, and inequitable practices.

In addition to experiencing the biasing factors cited above, most students who live in economically impoverished neighborhoods attend schools that do not offer many advanced math and science courses. Moreover, in schools that do offer such courses, tracking policies disproportionately divert student with lower grades and scores to lower-level science and math courses.

> In 2005, 6 percent of African-American and 7 percent of Hispanic high school graduates completed calculus, compared with 16 percent of white students and 31 percent of Asian-American students (Hill & Kearl, 2011).

Relatively little research clarifies how specifically to help African-American and Hispanic girls succeed in STEM subjects. What is suggested above applies to all girls. As highlighted below, some special projects have been initiated to improve the STEM-prep pathway for "minorities".

> In 2014, the Charles A. Dana Center "embarked on the design of an improved STEM-prep pathway by collaborating with faculty and other experts from around the country. This pathway will be supported by two new courses, *Reasoning with Functions I & II*, which prepare developmental-math-level students seeking STEM careers to enter calculus and succeed in future STEM coursework or other technical courses that require strong algebraic skills and a mastery of functions." http://www.utdanacenter.org/higher-education/new-mathways-project/new-mathways-project-curricular-materials/stem-prep-pathway-i-and-ii/
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> At Southern Methodist University (SMU), "the STEMPREP program recruits bright, science-minded minority middle school students for the two-summer classroom phase of the STEMPREP project, then provides high school students with summer opportunities at research labs. One hundred percent of STEMPREP project students who finish the program attend college and 83 percent go on to graduate school to become physicians, pharmacists, dentists, researchers or engineers." http://www.eurekalert.org/pub_releases/2014-07/smu-dod072314.php

However, research indicates that these type of special projects, programs, and initiatives have limited impact since they do little to address the racial, gender, and economic disparities that marginalize subgroups. Needed are fundamental shifts in institutional policies and practices.

With this in mind, schools must think strategically about how best to play a role in enhancing the pathway not only to STEM but to a promising future and not only for girls and underrepresented

minorities but for all students. To these ends, schools must expand school improvement to include a well-developed system of student and learning supports that is unified, comprehensive, and equitable (Adelman & Taylor, 2006; in press).* Such a system helps to personalize instruction and provide special assistance (including accommodations) as needed. Such a system not only can provide a better instructional fit, it facilitates student transitions by providing academic and social supports and quickly addresses school adjustment problems. And it enhances home involvement and engagement in the student's schooling. For effective implementation, the system must be fully embedded into school improvement policy and practice and include a continuing education facet for all school staff.

As noted above, a key facet of all this, from a psychological perspective, is minimizing threats to and maximizing strategies that enhance feelings of (a) competence, (b) self-determination, and (c) connections to significant others. At schools, a daily focus on these matters is essential, and schools need to work with students' families to enhance their understanding of how such a focus can help ameliorate problems and expand future opportunities.

Concluding Comments

A complex range of transacting factors underlies the STEM gender and racial gaps. Schools at all levels have a role to play in helping to improve the situation. However, the solution is not to tack on another special initiative.

The problems producing the imbalances in the STEM fields are multifaceted and overlapping and affect all students. Schools must approach them as an integral facet of school improvement policy and practice and in ways that enhance equity of opportunity for all students. To do less is to make a mockery of the *Every Student Succeeds Act*.

*For details about a *Unified, Comprehensive, and Equitable System of Learning Supports*, see

>*ESSA, Equity of Opportunity, and Addressing Barriers to Learning* – http://smhp.psych.ucla.edu/pdfdocs/essaanal.pdf

>*Piecemeal Policy Advocacy for Improving Schools Amounts to Tinkering and Works Against Fundamental System Transformation* – http://smhp.psych.ucla.edu/pdfdocs/tinkering.pdf

>All this is discussed in detail in a new book that is in press entitled: *Transforming Student and Learning Supports: Developing a Unified, Comprehensive, and Equitable System.* For a preview look at this book, send an email to Ltaylor@ucla.edu

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Appendix

Encouraging Girls in Math and Science

a What Work's Clearinghouse guide
http://ies.ed.gov/ncee/wwc/practiceguide.aspx?sid=5

The objective of this guide is to provide teachers with specific recommendations that can be carried out in the classroom without requiring systemic change. Other school personnel having direct contact with students, such as coaches, counselors, and principals, will also find the guide useful.

Recommendations

1. Teachers should explicitly teach students that academic abilities are expandable and improvable in order to enhance girls' beliefs about their abilities. Students who view their cognitive abilities as fixed from birth or unchangeable are more likely to experience decreased confidence and performance when faced with difficulties or setbacks. Students who are more confident about their abilities in math and science are more likely to choose elective math and science courses in high school and more likely to select math and science-related college majors and careers. Level of Evidence Moderate
2. Teachers should provide students with prescriptive, informational feedback regarding their performance. Prescriptive, informational feedback focuses on strategies, effort, and the process of learning (e.g., identifying gains in children's use of particular strategies or specific errors in problem solving). Such feedback enhances students' beliefs about their abilities, typically improves persistence, and improves performance on tasks. Level of Evidence Moderate
3. Teachers should expose girls to female role models who have achieved in math or science in order to promote positive beliefs regarding women's abilities in math and science. Even in elementary school, girls are aware of the stereotype that men are better in math and science than women are. Exposing girls to female role models (e.g., through biographies, guest speakers, or tutoring by older female students) can invalidate these stereotypes. Level of Evidence Minimal
4. Teachers can foster girls' long-term interest in math and science by choosing activities connecting math and science activities to careers in ways that do not reinforce existing gender stereotypes and choosing activities that spark initial curiosity about math and science content. Teachers can provide ongoing access to resources for students who continue to express interest in a topic after the class has moved on to other areas. Level of Evidence Moderate
5. Teachers should provide opportunities for students to engage in spatial skills training. Spatial skills training is associated with performance in mathematics and science. Level of Evidence Minimal

For links to the sources for each recommendation, go to
http://ies.ed.gov/ncee/wwc/practiceguide.aspx?sid=5