Representation in STEM – Research Summary

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Evidence tells us that lack of diversity in STEM (Science, Technology, Engineering, Mathematics) fields contributes to underrepresented students leaving these degree programs. In this research summary we review the matter of diversity in STEM—specifically with respect to race, ethnicity, gender, and disability—and how diversity in these disciplines, or lack thereof, affects STEM students. Fortunately, the situation is not hopeless; there are practical steps that can improve representation and, ultimately, learner outcomes.

In 2021, Pearson rolled out new editorial guidelines to ensure standards for content relating to race, ethnicity, gender, disability, social class, sexual orientation, and religion, with the aim to advance more diverse and inclusive learning experiences. We take our responsibility to our communities seriously. Research focused on representation in STEM supports and informs our standards and suggests that the improvements we have made to our content will have positive effects.

Representation in STEM fields matters

Many college students struggle with chronic levels of stress, depression, and anxiety; and these conditions are prevalent among students in STEM fields. The feelings of failure and loss of confidence associated with these mental health issues also correlate with dropping out of STEM degree programs (Hunter, 2019). STEM programs have gateway courses that are known to exhibit an unwelcoming climate and encourage students who do not initially succeed to switch majors (Chang et al., 2008). The greatest attrition rates occur among women (69% of high-achieving women that start a STEM major drop out, compared to 37% of men), and specifically women of color, despite achieving an overall grade point average of 3.5 or higher (Holland et al., 2019). This attrition compounds the lack of diversity in STEM fields. Underrepresented groups (Black, Hispanic, and other) hold only 20% of STEM jobs, despite holding 31% of all jobs in the United States (Fry, Kennedy, & Funk, 2021). [1] Black and Hispanic students earned 19% of STEM bachelor's degrees, significantly below their share of all bachelor's degrees—25% (Fry et al., 2021). Loss of confidence is often fueled by a lack of connection with the stereotypes associated with the major and lack of support from a social group.

[1] Asians make up 6% of the US workforce yet hold 13% of STEM jobs. Therefore, Asians are not considered underrepresented in STEM fields.

However, representation of a diverse range of scientists can have substantial impact on learner outcomes and motivation to continue pursuing STEM fields (Hurtado et al., 2010). Research shows that several practices enhance the retention and success of underrepresented students in STEM programs. For example, representing diversity in educational materials, matching underrepresented students with identity-similar mentors, and highlighting the accomplishments of underrepresented scientists can all help students build a stronger sense of belonging in STEM. Furthermore, STEM textbooks can help to counteract the historical complexities of racism, sexism, and bigotry by spotlighting diverse leaders in educational contexts (Dillard-Wright & Gazaway, 2021). These issues are primarily studied in the United States higher education system; however, concerns around inequalities within STEM fields exist on a global scale. Therefore, promoting diversity and inclusion in these fields is critical to challenging systemic racism and changing societal biases.

> *"Scientists who identify with underrepresented groups, and even how we define underrepresented in science, differs across geographic regions, underscoring the importance of additional research and teaching that addresses localized issues of representation"* - Simpson, Beatty, & Ballen, 2020

Race and ethnicity representation in STEM

Compared to majority-group peers, students from underrepresented racial and ethnic backgrounds were more likely to withdraw from STEM degree programs (Seymour & Hunter, 2019), likely due to stereotypes and inequalities underrepresented students face in higher education. Students as young as 8 years old show stereotypical attitudes towards scientific roles, describing the typical scientist as a white, older man (Chambers, 1983; Jones, Howe, & Rua, 1999). Research measuring "what a scientist looks like" over the past 5 decades shows that perceptions of race and gender associated with science have not significantly changed, and many students (regardless of their race, ethnicity) continue to stereotype a scientist as a white man (Finson, 2002). Representation of racially and ethnically diverse role models in STEM fields is necessary to counter the stereotypes of what defines a successful scientist, leading to higher feelings of belonging within the STEM field for more students (Simpson et al., 2020).

Citation Biases and Racial/Ethnic Inequality

Science textbooks published in the last 20 years do not represent the changing demographic landscape of scientists from underrepresented racial and ethnic groups.

- Only 8% of scientists cited in the last 20 years in scientific textbooks were scientists of color, a non-significant increase over the last century despite significantly more non-white scientists publishing in the field (Wood et al., 2020).

Skin Type Diversity

Medical textbooks have lacked skin type diversity when showing dermatological presentation of diseases. Lack of diversity could lead to under-diagnosis or misdiagnosis of conditions for dark-skinned patients (Lester et al., 2019).

- Only 4.5% of images included in the medical textbooks analyzed showed dark skin (Adelekun, Onyekaba, & Lipoff, 2021). Of the dark-skinned images included, most represented severe stages of infectious diseases (such as syphilis). Greater access to high-quality images of diverse skin types for each stage of a disease is necessary to improve diagnoses.
- Among 182 images collected from eight popular human sexuality textbooks, only 1.1% represented dark skin tones (Rosenstock Gonzalez, Williams, & Herbenick, 2021).
- Among 4,146 images analyzed from four popular medical textbooks, only 4.5% contained images of dark skin and 21% showed medium toned skin (Louie & Wilkes, 2018). None of the images at a chapter or topic level showed skin tone diversity.

Scientific Spotlights – Racial Diversity

- Representing hidden identities of multiracial and underrepresented scientists through scientific spotlights (descriptions highlighting a scientist's background and work along with an image of the scientist) could change stereotypes of the typical scientist. For example, a study from a community college that mainly serves socioeconomically challenged students suggests it is helpful to regularly present students with information about diverse scientists in STEM. Sharing scientific spotlights has been associated with improving students' connection to scientific fields (Schinske et al., 2016). Furthermore, students reflect on their own biases and build a stronger STEM identity when the scientific spotlight highlights the scientist's interests and background, and when meta-cognitive questions are also included in the exercise to encourage reflection. Presenting first-year biology students with "Scientific Spotlight" features that highlight racially and ethnically diverse scientists was correlated with students earning higher course grades and reporting non-stereotypical views of what a scientist looks like (Schinske et al., 2016). The "Scientific Spotlight" features included the scientist's background and one of the scientist's research articles. In conjunction with the feature, students were asked to respond to several prompts that surveyed their perceptions of scientists. (See below supplemental information.)
- 90% of students who listened to a podcast spotlighting a diverse range of scientists (diverse in racial and gender profiles) reported that the podcast changed their perspective of who represents a scientist (Yonas, Sleeth, & Cotner, 2020).
- Providing 9th grade students with counter-stereotypical examples of scientists in class shifted their perceptions of scientists and bolstered students' science identity and performance (Krajkovich & Smith, 1982; Scherz & Oren, 2006).
- High school students from underrepresented racial backgrounds reported a greater sense of belonging in math when surrounded by similar racial/ethnic peers (Morales-Chicas & Graham, 2021) and instructors (Egalite et al., 2015).

Gender representation in STEM

Women are less likely to pursue STEM careers due to social norms and stereotypes—including discrimination in the workplace and lack of existing female representation in the field (Dasgupta & Stout, 2014). Lack of female scientists has led to a stereotype learned early in childhood that STEM careers are for men. An analysis of 78 studies asking children to draw a scientist shows that both female and male children (especially older children) are most likely to depict a scientist as male (Miller et al., 2018). Although the percentage of drawings depicting male scientists has decreased over the last 5

decades, female STEM representation has not significantly increased. STEM careers are currently dominated by men; therefore, women pursuing a STEM career are less likely to be exposed to female mentors and leaders in their educational experience.

Citation Biases and Gender Inequality

Based on a sampling of popular chemistry textbooks distributed in the United States, images and stories of female scientists are underrepresented in STEM textbooks. Although more female scientists hold STEM careers today compared to decades past, this disparity in female representation is attributed to the lack of attention towards contributions from female scientists.

- A male scientist is mentioned on average every 4 pages, while a female scientist is mentioned every 250 pages (Becker & Nilsson, 2021).
- 65% of images contained a male scientist, while only 24% contained a female scientist (Becker & Nilsson, 2021).
- 60% of students awarded undergraduate biology degrees identify as women, however only 14% of women scientists are featured in biology textbooks (Wood et al., 2020).

Female Mentorship

Scientific socialization is important. It is well documented that when girls encounter women in STEM and see women depicted in STEM, they are more likely to cultivate a sense of belonging in STEM. Mentoring is an important part of this socialization.

- Having a fellow female mentor correlates with better retention rates, as well as greater feelings of belonging and higher self-efficacy, compared to a male mentor or no mentor (Dennehy & Dasgupta, 2017).
- Women who were mentored by women reported maintaining belonging to the STEM field after the mentorship, whereas women mentored by men showed decreased belonging (Dasgupta & Stout, 2014).
- Female math majors who receive mentorship from a female peer demonstrate more positive attitudes towards math and increased effort on math tests compared to women mentored by male peers (Stout et al., 2011).

Scientific Spotlights – Female Scientists

Exposure to same-sex experts is beneficial, especially for female STEM majors, to promote feelings of connectedness between the expert and self and makes future careers in STEM plausible. Representation of women in STEM careers increases the sense of belonging and challenges stereotypic assumptions about women's capabilities (see Supplemental for more information about Scientific Spotlights).

- Female engineers who received scientific spotlights on influential female engineers (compared with male engineers or engineering innovations) showed greater implicit positive attitudes toward STEM (Stout et al., 2011).
- Increased exposure to same-sex spotlights correlated with higher motivation to pursue a STEM career (Stout et al., 2011).
- Undergraduate students exposed to famous women in STEM expressed automatic counter-stereotypical beliefs about women (Dasgupta & Asgari, 2004).

- Women showed higher math scores after reading information that acknowledged stereotype threat and highlighted women's achievements in STEM, whereas women who read information that only discusses stereotype threat showed worse math scores (Shaffer, Marx, & Prislin, 2012).

Disability representation in STEM

People with disabilities are underrepresented in higher education, especially in STEM fields. Based on an analysis of the Higher Education Statistics Agency (HESA; United Kingdom), the proportion of learners pursing a STEM degree who identify as having a physical or mental disability has grown in the last decade, rising from 6.5% in 2008 to 15.5% in 2019 (Joice & Tetlow, 2021). However, the percentage of students with disabilities has grown at a slower rate in STEM majors compared to non-STEM majors (Hawley et al., 2014) and STEM students with disabilities show higher dropout rates compared to students without disabilities (NSF, 2017). Overall, only 7.8% of STEM doctoral graduates report having a disability, despite 25% of the US adult population reporting a disability (NSF, 2017; Okoro et al., 2018). Representation of scientists with disabilities in STEM fields and mentorship programs for students who identify as disabled may improve student retention and success in STEM fields.

Representation of Disabilities in Textbooks

Textbooks lack inclusive descriptions of disability content (e.g., information about care, diagnosis, and general knowledge about the spectrum of physical and mental disabilities) and commonly promote negative, stereotypical images of people with disabilities by primarily depicting individuals with severe physical disabilities and who are incapacitated (Smeltzer et al., 2010). More attention should be placed on how patients are represented in instructional content to influence patient care in real-world settings.

- People with physical disabilities were represented in 29% of Norwegian biology textbooks (Jensen, Herrebrøden, & Andreassen, 2021).
- Multiple reviews of research related to disability education in nursing suggests that textbooks lack representation of a variety of physical and mental disabilities, leading to inadequate quality of care (Bourne, Smeltzer, & Kelly, 2021; Boyles, Bailey, & Mossey, 2008).
- Of 4,015 images illustrated in primary school English-language learning textbooks, only 21 images of physically disabled people were found and of these, only two represented children with physical disabilities (Hodkinson, Ghajarieh, & Salami, 2018).

Retention for Students with Disabilities

- Researchers at the Center for Sensorimotor Neural Engineering (CSNE), an Engineering Research Center at the University of Washington, took a multi-pronged approach to promoting the inclusion of individuals with disabilities at the center, and several of their practices addressed representation (Bellman, Brugstahler, & Chudler, 2018). Specifically, they prioritized recruitment of individuals with disabilities onto advisory boards, produced material highlighting the achievements of individuals with disabilities, and ensured individuals with disabilities were represented on their promotional materials and images. Data suggested that CSNE had higher engagement of individuals with disabilities compared to other NSF-funded Engineering Research Centers.

Mentorship for Students with Disabilities

- An analysis of four case studies of successful mentorship programs for students with disabilities indicated that the availability of local role models with disabilities was a crucial factor of these programs (Stumbo et al., 2011). Making these connections allows students with disabilities to hear about the experiences of individuals with similar disabilities who have been successful in college and their careers. This can help students feel more confident in their own progress and potential and give them strategies that can help navigate challenges they may face as they transition to college and the workforce.
- Students with disabilities reported greater self-advocacy and self-determination after a 4-year online mentoring program (Gregg et al., 2016; 2017). Students met online regularly with non-disabled mentors from racially minority backgrounds who hold a career in the relevant STEM field. Mentors connected with students as underrepresented scientists who experienced discrimination. More research is needed to understand if STEM mentors with disabilities would show greater benefits to students with disabilities.

The path forward

Representation is vitally important to ensure everyone has the opportunity to succeed in a career in STEM. By diversifying the scholars represented in textbooks, all students can have a better understanding of the variation of what a scientist looks like. Research also shows that representation improves student retention and belonging, leading to a more diverse field of future scientists. Small efforts can make a big difference to help students feel included.

Pearson has an ongoing and long-term focus on supporting these advancements. One example is the use of the term 'Master/Slave', commonly used in engineering and computer science fields. Pearson is leading the industry by removing this terminology from hundreds of titles, working with engineering and computer science organizations to stop its use in other contexts. Another example comes from medical microbiology. We have added numerous photos that show people of color with various skin conditions to help students recognize these conditions on a range of skin types. We also emphasize the diversity that exists in our valued allied health professionals. Together we can move from a position of ‘do no harm’ to ‘do better’ and make a real difference to improve the experience for all learners.

Supplemental

Scientific Spotlight Description

Example from Schinske et al. (2016):

Ben Barres is a Stanford professor of neurobiology. He studies diseases related to signaling in the nervous system, and in particular the roles of supporting cells around neurons. Dr. Barres is also a leader

in science equity and the effort to address gender gaps. He is uniquely positioned to address these issues, since he has presented both as a female and a male scientist at different times in his career.

1. View the *Wall Street Journal* article about Ben Barres by clicking here (Begley, 2006).

2. Then, review Dr. Barres' article in the journal *Nature* by clicking here (Allen and Barres, 2009). (If you are interested in hearing more from Ben Barres, you can search for him on YouTube. He has videos on his research and on his experiences as a transgender person.)

After reviewing these resources, write a 350-word or more reflection with your responses to what you saw. Discuss:

1. What was most interesting or most confusing about the articles you read about Dr. Barres?
2. What can you learn about neuron signaling (action potentials, synapses, supporting cells) from these articles?
3. What do these articles tell you about the types of people that do science?
4. What new questions do you have after reviewing these articles?

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