Investigating Physics Self-Belief of Female African-American Students

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Female African Americans comprise an underrepresented group in physics-focused careers. Between 2002 and 2012 African-American women comprised approximately 1% of graduating physics majors in the United States.[1] It appears that at some point in their educational careers, many female African-American students stop considering the field of physics as being a viable or attractive option. One approach to garnering a greater understanding of this phenomenon is to specifically look into the impact of their self-belief; this encompasses students' attitudes, self-concept, and self-efficacy. Self-concept refers to how one views one's own strengths and weaknesses, while self-efficacy refers to one's capacity to believe in one's own abilities to succeed in specific situations. There does not yet exist a large body of research that specifically concentrates on middle and high school-aged female African Americans, low physics representation, and its connection to self-belief related to physics. In this instance, the question is: "Do these students believe they can succeed in physics?" This research investigates the levels of physics self-belief of female African Americans who are enrolled in middle and high school physics.

Previous investigations

Few published studies focus on female African-American underrepresentation in physics and its connection to a self-belief related to physics. There does exist, however, a body of research investigating the experiences of marginalized groups in physics and ways to facilitate the inclusion of underrepresented populations. Hazari et al.[2] write about the importance of teachers, in particular high school teachers, helping female students cultivate their own physics identity. In this instance, physics identity refers to a person seeing herself as being a physicist. They found that recognition from high school teachers increases the likelihood of their female students to pursue physics majors in college. The authors lastly point out that students feel the most recognition with high standards and acknowledgment when these are met. Johnson et al.[1] advise physics teachers and faculty to be aware of common experiences that affect women of color in STEM fields; these experiences include feelings of isolation, implicit biases, stereotype threat, and microaggressions. The authors explain that physics faculty should create safe and comfortable environments, implement research-based teaching approaches, and be conscious of their own biases.

Farinde and Lewis[3] give advice to teachers regarding how to help prevent their African-American female students from accepting that their ability in science, technology, engineering, and mathematics (STEM) topics are due to racial or sex inferiorities. There also exist in the literature some studies whose focus is a bit more tangentially related to our investigation but are still relevant. Brown et al.[4] investigated STEM self-efficacy of middle school students by gender using individual and collaborative surveys, and Nissen and Shemwell[5] consider the causes for a decrease in female physics self-efficacy vs. male physics self-efficacy in introductory college-level physics utilizing a data collection technique called Experience Sampling Method (ESM). Rifken[6] discusses the importance of pointing out to students the "who" of physics in an attempt to illustrate that physics is not solely done by white male Europeans. He introduces a two-week project that revolves around his students investigating current demographics within the physics community. This is used as a means to create dialogue about diversity and race, while also highlighting influential physicists who come from marginalized groups. Rifken cites that this project was seen by most students to be a worthwhile endeavor.

Overall, these previous studies have shown that teachers and the methods of physics instruction can greatly affect female experiences in class. This in turn can influence the physics-related self-belief of the student, which has shown to be a significant contributor in the interest, pursuit, and retention of students in physics. Instructional techniques that

1. I feel that I understand most topics in physics.
2. I am interested in and enjoy physics.
3. I feel confident when asked to solve physics problems.
4. I feel I can learn the necessary skills to succeed in physics.
5. I feel that when I take a physics course, I will succeed.
6. I often find myself lost or confused during a physics lecture.
7. I can see myself having a career in physics if I wanted.
8. I would like to see more professionals in physics who are like myself.
9. In school, I have had a positive role model who works in the field of science.
10. What obstacles do you think you would face as a female African American if you wish to pursue physics as a future career?

Fig. 1. The completed survey. Statements 1 through 9 are based on a Likert-type scale, 1 being strongly disagree and 7 being strongly agree. Question 10 is a qualitative open-ended response.

 DOI: 10.1119/1.5055326

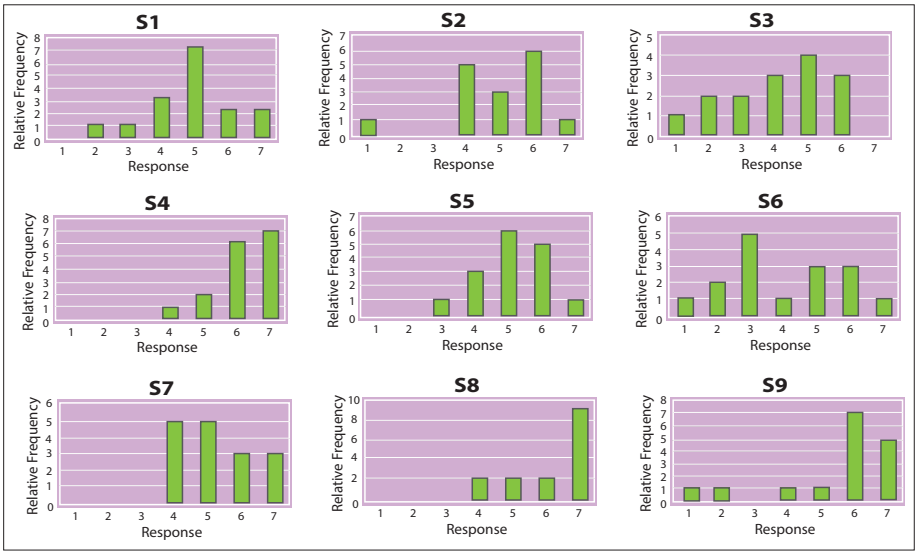

Fig. 2. These histograms correspond to statements 1 through 9, e.g., S1 corresponds to Statement 1. The histogram illustrates how frequently an answer was recorded in response to a statement. High frequency is indicated by taller bars, while lower frequency is shown by shorter bars.

situate students as active participants in the learning process, challenge students to pursue higher standards, and focus on inclusion and diversity can improve female students' attitudes towards physics.

Study description

To investigate our population's feelings about physics, we designed a survey composed of nine quantitative statements and one qualitative open-ended response. The survey can be seen in full in Fig. 1. The quantitative statements were based on a Likert-type scale, where 1 is strongly disagree and 7 is strongly agree. The components of the survey were meant to explore students' physics self-belief, such as identifying how students felt toward and understood physics from their experiences in their physics course, as well as to explore how they feel about physics as a viable future career. Due to geographic constraints as well as the preliminary nature of the investigation, we chose to administer the survey in two schools, from which we gathered a population of 16 female African-American students. The schools differed in demographics: One is a middle school in which 45% of the students are African American, while the other is a high school with a 7% African-American student population; this school is predominately white.

Results

Once the surveys were completed, we analyzed the data, looking for trends or themes. The findings were best illustrated in the form of histograms, graphs that represent the frequency of a response. These histograms can be seen in Fig. 2. From examining the histograms, we notice that the students' responses are consistent with indicating that their physics self-belief was positive in nature; for example, students tend to agree with statements 2 ("I am interested in and enjoy physics") and 4 ("I feel I can learn the necessary skills to succeed in physics"). Furthermore, students disagree more with statement 6 ("I often find myself lost or confused during a physics lecture"); these data highlight the self-concept that physics is an area of strength for them. In the qualitative data from item 10, which asks students to identify potential obstacles if they desired to pursue a physics-focused career, stereotype seemed to be a major theme. This was shown through multiple uses of language which indicated that students foresaw themselves needing to deal with external racist or sexist biases, e.g., from coworkers or employers. Examples of responses can be found in Fig. 3 and were selected based on their clarity and overall representation of the qualitative data.

Discussion and implication for teachers

The results show an interesting juxtaposition. Responses from the quantitative sections of surveys reflected generally positive attitudes, self-concept, and self-efficacy in the context of physics. These answers indicate that students like and believe they can succeed in physics. In contrast, written responses to item 10 cited several internal and external hurdles. Students referred to potential racial and/or sexist biases from others in physics, as well as anxiety related to hypothetically dealing with such biases. Looking at these two apparently contradictory feelings, it may be that these students in fact have a physics self-belief that could encourage them to pursue physics-focused careers; however, their awareness or perceived awareness of racial and sexist biases creates a substantial deterrent. With this in mind, it is possible that an underrepresentation of female African Americans may not be due to a lack of interest.

- *"As an African American female people wouldn't take me seriously. Such as having my statement ignored or being overlooked for certain places in jobs."*
- *"I will be looked down upon. I will be underestimated, especially since I'm a girl and African American."*
- *"That people might talk down or try to belittle me, treat me like I don't know what I'm doing."*
- *"People who don't want someone like me to pursue physics as a future career because it goes against what they think."*

Fig. 3. These responses have been taken verbatim from submitted surveys. They were chosen for their clarity and overall representation of the qualitative data.

Instead, a perceived hostile work environment can be identified as a key reason why young female African Americans often do not pursue physics-focused careers. It appears that these students like physics and think they are good at it, but they still don't think they can be physicists.

This perception does not stem from a lack of ability or skill. Students indicated in their survey responses that they see themselves having the potential of developing the necessary skills to succeed in physics. We suspect the juxtaposition may be due to students not yet having fully developed their physics identity, as shown in Hazari et al.[2] This study claims that in order for students to effectively develop their physics identity, the teacher must recognize their abilities and act as a facilitator. In addition, potentially hostile situations are clearly identified as being a source of stress and anxiety. This connects to previous work[1] that identified comfortable environments as being critical in the retention of women of color in physics.

These results represent a step toward understanding a complex issue that the physics community currently faces. Creating a healthy and nonthreatening environment is crucial in increasing diversity and equity for all marginalized persons in physics. For teachers, this is a constant battle that must be consciously considered whenever in the classroom or interacting with students. We believe it is important to know how our students feel about physics, and it may be a fruitful pursuit for teachers to create surveys similar to the one described here for their classrooms. This will allow educators the opportunity to gather an understanding of their students' attitudes towards physics and what it means to be a physicist. Additionally, helping students develop their physics identity is an important role to which physics teachers must commit. This can be done through setting high standards, as well as acknowledging students who meet or exceed these standards. There is a powerful relationship between the recognition by others, in particular by physics teachers, and students seeing themselves as a "physics person."[2] Instructors obviously cannot completely eliminate the potentially hostile work environment that underrepresented students may enter, and the deterring effect this has on learners is mostly out of an educator's control as well. However, teachers can take steps to make their own classrooms a safe and healthy place for all students. Directly addressing microaggressions, affirming female African-American students, emphasizing that physics can be mastered through practice as opposed to inherent skill, as well as rejecting established stereotypes can help create a productive learning environment for all students.[1] Furthermore, to reduce feelings of isolation, it is important for teachers to facilitate opportunities for students to socially interact, both in and outside the classroom.

Teachers can also make a greater effort in highlighting the diversity that does exist in the physics community. The survey responses from item 8 (want to see more physicists like themselves) and 9 (currently have a physics role model in their school) in Fig. 2 indicate that while some students cite that they have positive role models in science, many also reflect that they would like to see more physicists who are like them. This shows that educators should do more to expose students to diverse potential role models. One way this can be accomplished is through utilizing pop culture. Movies and television shows, such as "Hidden Figures"[7] and "Cosmos"[8] feature influential female and male African-American physicists. Another possibility is setting up enrichment opportunities, such as a classroom Skype call with female African-American physicists. These options broaden the current understanding of what physicists look like, helping students find more diverse role models. It is also imperative for educators to actively avoid stereotype threat, a situation in which people feel themselves at risk of conforming to stereotypes that relate to their particular group. Aronson et al.[9] highlight that underrepresented students who are aware of a stereotype threat relevant to their group experience a negative impact on their performance in and engagement with academics. These instances of stereotype threat often can occur implicitly (but no less harmfully) if teachers are not mindful in choosing the words that are used in their interactions with students. An example could be exclusively using the pronoun "he" on homework problems. This creates the implication that only men are involved in physics.

Finally, an important concept that all teachers must consider is eloquently explained by Christopher Emdin, "The reality is that we privilege people who look and act like us and perceive those who don't as different and, frequently, inferior."[10] In an interview about the book from which that quote is taken, Emdin expounds further:

> Reality pedagogy is an approach to teaching and learning that focuses on the realities of youth experiences as the anchor of instruction. It's the idea that every young person who comes into the classroom has realities that vary from the realities of the teacher, especially if that teacher is from a different ethnic, racial, cultural and socioeconomic background. It holds that uniqueness about the youth experience as a fundamental and essential piece of teaching and learning. Before you teach content, you first teach to understand the youth experience. If you understand the youth experience, that allows you to deliver content more effectively and that better allows you to deal with classroom management.[11]

In essence, Emdin cites the importance of teachers self-reflecting and recognizing that every person—students and teachers alike—has her own unique experiences, cultural biases, and worldview. It is vital for an educator to remain cognizant of these biases and transcend them in order to create an instructional setting in which each student can effectively learn, acquire a lifelong interest in physics, and feel like he or she can succeed in a physics-focused career.

Limitations of the study

The sample size of this data set is small, with 16 participants, which limits the generalizability of the findings. This research study cannot reasonably be interpreted as a universal reflection of the female African-American experience in physics, nor can it be used as an indication that the physics self-belief of this study population can be used to reflect the physics self-belief of female African Americans on a national scale. However, the results show these particular students' feelings towards physics in their local community. We hope in a larger follow-up study to gather data from an increased number of schools and communities, which will allow for a more generalizable conclusion.

Summary

Often, the amount of work that is required to open the physics community to more diverse members seems daunting. However, we as educators have opportunities to encourage and enhance diversity within physics. It is important for us to consider how marginalized students feel, and how to actively support them. This investigation represents a step towards better understanding these students' attitudes towards physics, and we encourage educators to consider the immense impact physics self-belief can have in all students, especially learners from underrepresented groups.

Acknowledgment

We would like to thank Brianna Santangelo for her assistance in administering surveys to participating schools.

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