QUARKNET STEP UP: WOMEN IN PHYSICS
TEACHER NOTES

DESCRIPTION

In this activity students **examine the conditions for women in physics**, **discuss gender issues** with respect to famous physicists, **describe gendered professions** (that is, professions associated with specific genders), and **discuss personal experiences** with gender stereotypes and bias. Data include women in physics around the world and the role of culture and society in gender issues.

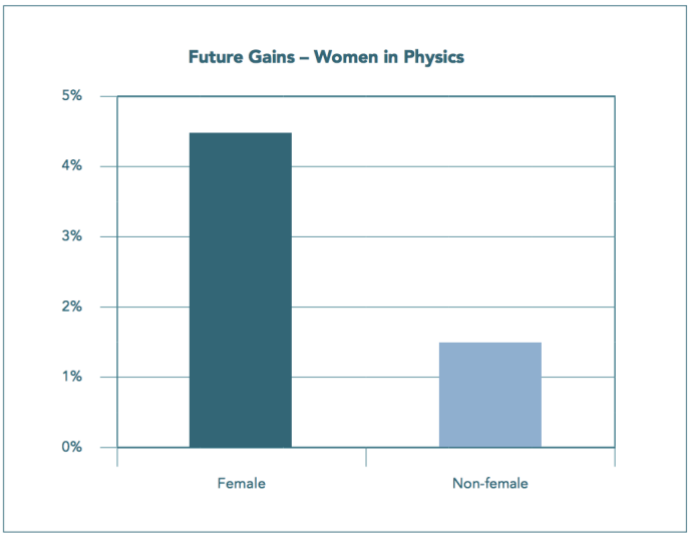

Figure 1. *Percentage gains in female and non-female students' future physics intentions (towards majoring/pursuing a career) due to the lesson.*

The research on this lesson has shown that using this lesson improves students' future physics intentions (e.g., majoring in physics in college, intending physics-related careers) in classes across the United States (N = 823 students). Figure 1 shows that both female and non-female students have positive gains from the lesson (Cheng et al., 2018).

STANDARDS ADDRESSED

Next Generation Science Standards
Appendix F – Science and Engineering Practices in the NGSS
Engaging in Argument from Evidence

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
- Construct, use, and/or present an oral and written argument or counterargument based on data and evidence.

Appendix H – Understandings about the Nature of Science
Science is a Human Endeavor

- Scientific knowledge is a result of human endeavor, imagination, and creativity.
- Individuals and teams from many nations and cultures have contributed to science and to advances in engineering.
- Science and engineering are influenced by society and society is influenced by science and engineering.

ENDURING UNDERSTANDINGS

Awareness of the effects of unconscious bias can lead to a more inclusive environment in physics.

LEARNING OBJECTIVES

Students will know and be able to:

- Describe trends of numbers of women earning physics degrees in the U.S. and internationally.
- Describe gender inequalities present in today's society that impact the choice of physics as a career.
- Give examples of unconscious bias and conscious bias.
- Describe the effect of unconscious bias on career choice.
- Explain their own views on the current state of women in physics.
- Participate in a productive discussion in which they share examples of bias, respectively listen to their peers and support claims with evidence.

Extension

- Provide reasoning to support or deny the claim that "in addition to gender-based discrimination, students from underrepresented groups also experience unconscious bias."

PRIOR KNOWLEDGE

Your student should be familiar with the concepts covered in *QuarkNet: Changing the Culture* and in the *QuarkNet STEP UP: Careers in Physics* activity.

BACKGROUND MATERIAL

- Information about the STEP UP program

RESOURCES/ MATERIALS

- Class whiteboard, projector, computer
- Women in Physics presentation slides
- A document that can be projected/shared to develop classroom strategies
- Pieces of paper for writing prompt activities (two per student)
- (Optional) Devices with Internet access to participate in polls
- Women in Physics Pre-Assignment and Women in Physics Post-Assignment handouts
- Women in Physics Pre-Assignment and Women in Physics Post-Assignment handouts (Print one per student.)
- Group Tasks for Women in Physics (Print one per student.)

IMPLEMENTATION

To prepare read *Women in Physics Internationally, Appendix 4*, before implementing the lesson. Teachers who have previously taught this lesson felt more comfortable having more information for themselves beforehand.

Establish a safe and supportive classroom environment before doing the *Women in Physics* activity. Using the activity *QuarkNet: Changing the Culture* will help. Student sharing of personal experiences of conscious and unconscious bias is critical to understanding and shaping their own pathways as well as impacting their peer's conception of career pathways. The structure of small group and larger discussion around anonymously submitted answers supports developing a culture of openness in discussing challenging topics.

This activity is divided into three tasks that center around gathering and discussing data and then relating this to real-life personal or peer experiences. Please note that **Task 3,** the personal reflection and classroom discussion, is the most important piece in encouraging students to pursue a career in physics. It is essential that your students complete **Task 3**. In Task 2, the item numbers refer to the sections of the *Group Tasks for Women in Physics* document.

Task 1: Historical Role of Women in Physics and Discussion Guidelines
We recommended that students complete the Women in Physics Pre-Assignment as homework, prior to class. The assignment involves an Internet search, reading of biographies and responding to prompts.

First, remind the class of the *Guidelines for Conduct During Discussions* covered in the QuarkNet: *Changing the Culture* Activity. Then, students share their responses to the pre-assignment in groups of two or three. A representative from each group reports out a summary of their group's responses. Make a running list of group responses to each question on the board, on poster paper or on a slide. Continue to add to these lists throughout the activity.

Physicist	Contributions	Obstacles	Challenges today: Easier? Harder? Different?

Task 2: Data on Women in Physics (See options in the Student Group Tasks document)
Continuing with the small groups from **Task 1**, assign students to or have them choose one item at random to study. The *Student Group Tasks for Women in Physics* handout will guide their work. All students should have access to all the slides. Each group decides on answers to the prompts and shares their results with the class. There are optional slides that correspond to the group tasks. When you call time, have each group describe their topic and explain to the class their group responses.

The topics from the Group Tasks are listed along with possible claims that students may make in each area:

1. Data on international women in physics
   Students will be surprised that Iran has the highest percentage of female physics degrees granted. They will also be surprised that the U.S. is among the lowest percentage of female physics degrees granted. Claims may include that women are not as intelligent as men, cultural attitudes prevent women from pursuing science degrees, women naturally prefer "helping careers."
2. Gendered Professions
   Possible student claims may include: doctors, nurses and teachers are more likely to be women. Surgeons and specialists are more likely to be men. Scientists, engineers and mathematicians are more likely to be men. Claims include cultural expectations for men and women push women into "helping careers" and men into "more inventive" fields.
3. Data on undergraduate women in STEM fields in the U.S.
   Possible student claims may include: choosing biology and/or chemistry majors will increase their chances of getting into medical school. Choosing math, physics and engineering less often is likely because they perceive the material is much harder. Questions may arise about the cause of the negative slope in all of the graphs after about 2005.
4. Examples of gender inequalities (Academic Achievement)
   Possible student claims may include: there are unconscious biases that cause women to be viewed as not as smart as men. These include the notion that women get lower grades, women are not as smart as men, women are underprepared for these "hard" courses.

5. Defining Unconscious Bias
   Possible student claims may include: people who study physics are smarter than other people, or females cannot write as well as men. The differences in women participation in STEM fields is entirely due to sexism.
6. Intersection of Race/Ethnicity and Gender
   Possible student claims may include: there is a strong bias towards white students and Asian students; Black, Hispanic and Native American students are not encouraged to pursue physics. There is a bias that Black, Hispanic and Native American students are not smart enough to study physics. Over time, there is an increase in Hispanic students receiving physics degrees but there is very little change in the number of Black students receiving physics degrees. This suggests that there is a greater bias against Black students than Hispanic student.

Task 3: Reflection and Strategies

The data examination and sharing in Task 2 has prepared the class for this critical portion–relating to this data through personal experiences. Task 3 is divided into a few different sections with a variety of implementation strategies possible. Of critical importance are having the students share personal reflections (with an anonymous option) and a whole class discussion using evidence to discuss bias. The research shows that the most important technique for changing attitudes related to the role of women in physics is the discussion of real bias experienced (Lock, R. M., Hazari, Z. Phys. Rev. Phys. Educ. Res. 12, 020101 – Published 5 July 2016).

Personal Reflection Writing Prompt

Students respond to a prompt in writing and share with a neighbor.
Prompts for discussion:

a) Describe experiences you or a friend has had related to science and gender issues.
   Examples:
   - Who do you feel comfortable working with in class?
   - Do you feel more comfortable in any particular class?
   - Have you felt your abilities were questioned?
   - Have you seen or experienced gender biases in your own life, either purposeful or unintentional?

b) Do you think societal beliefs related to gender have any influence on the career you want to pursue? or careers you would not consider?

c) What can be done to support diversity in physics? What could you do?

Whole Group Discussion: Essential step!

Students now share another response anonymously, on a second piece of paper. You can then collect the papers and read them out to prompt discussion. If you are concerned about students being shy to speak up, another approach is to hand the papers out randomly and ask for students to read them. Then, ask for a show of hands from the students who have a similar response on their paper. Another way to encourage more sharing is by relating a time in your life, or a friend or colleague's, when you/they experienced bias. Additional tips to facilitate discussion, such as utilizing online tools, are available in the STEP UP Teacher Guide.

Proposing Strategies for Decreasing Bias

Begin by giving the following prompt and allowing students to write, discuss in groups or as a class: What can be done to support diversity in physics? What could you do?
Possible answers include:

- Encouraging peers to take physics.

- Encouraging everyone to participate.
- Making sure conversations and activities are not dominated by any individual.
- Encouraging classmates but letting them figure things out for themselves.
- Supporting diversity is not important. (Suggested counterpoints in this situation are: (1) Diverse teams produce better results. Follow the link for the reference; (2) Our current STEM workforce is insufficient. Again, follow the link for the reference. If we do not actively recruit women, we could be missing out on half of the potential workforce.)
- Giving help to women who are struggling in class. Use caution with this technique, the counterpoint is that this could undermine women's capabilities if you think they always need help.

Post-Assignment

Have students complete the post-assignment as homework.

ASSESSMENT

This lesson has opportunities for both formative and summative assessment:

- Students' pre-lesson essays about famous female physicists and their views about women in science today provide a formative assessment.
- Student's personal reflections should be kept private and assessment should only be for completion.
- Students' responses during the whole class discussion during which they share their views about famous scientists, gendered professions, and classroom experiences provide opportunities for formative assessment.
- Students' post-lesson essays about women in physics in the present day is a good summative assessment opportunity.

BIBLIOGRAPHY

- Next Generation Science Standards – Appendix F on Science and Engineering Practices. Retrieved from http://static.nsta.org/ngss/20130509/AppendixF-ScienceAndEngineeringPracticesInTheNGSS_0.pdf
- Next Generation Science Standards – Appendix H on the Nature of Science. Retrieved from: https://www.nextgenscience.org/sites/default/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf

Physicist information websites:

- Lise Meitner: https://www.sdsc.edu/ScienceWomen/meitner.html
- Jocelyn Bell Burnell: biography.com/people/jocelyn-bell-burnell-9206018

Data on race and ethnicity:

- Data on underrepresented minorities among undergraduates: aip.org/statistics/undergraduate/minorities
- Graph of physical science bachelor's degrees earned by African Americans: aip.org/statistics/data-graphics/trends-bachelor%E2%80%99s-degrees-earned-african-americans-physical-science-fields
- Graph of physical science bachelor's degrees earned by Hispanic Americans: aip.org/statistics/data-graphics/trends-bachelor%E2%80%99s-degrees-earned-hispanics-physical-science-fields-2002

Why women have a higher representation in some countries:

- https://blogs.scientificamerican.com/voices/countries-with-less-gender-equity-have-more-women-in-stem-huh/