Women in Physics

TEACHER GUIDE

STEP UP

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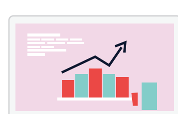
QUICK REFERENCE GUIDE

Help students **examine the conditions for women in physics** and **discuss gender issues** with respect to famous physicists, gendered professions, and personal experience to **neutralize the effect of stereotypes and bias**. Students participate in an interactive presentation by the teacher, in which data about women in physics around the world are discussed. The role of culture and society are considered.

1. Students complete a pre-assignment including an internet search for physicists, reading 2 biographies of historical & modern physicists, and completing a reflection.

2. **CRITICAL COMPONENT:** Guidelines for Classroom Discussion are introduced or referenced.

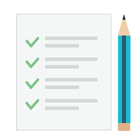
3. Students participate in an interactive presentation, during which the teacher shares data on women in physics around the world and the class discusses the role of unconscious bias, society & culture.



4. **CRITICAL COMPONENT:** Students voluntarily contribute their own experiences with gender bias and synthesize conclusions in a discussion with the entire class.

5. Students come up with strategies to support diversity in physics and are asked to enact the best strategies proposed.

6. Students complete a reflection on their views after the class discussion



Learn more at STEPUPphysics.org and register to access instructional support & FAQs.

WOMEN IN PHYSICS SUPPORTING RESEARCH

Lesson Topic: In this lesson, students will examine the conditions for women in physics drawing on current statistics/research and their experiences with physics. The goal of the lesson is to help students reflect and think critically about the issue in order to neutralize the effect of bias, particularly for female students.

Lesson Evidence: This lesson has been shown to improve students' future physics intentions (e.g. majoring in physics in college, intending physics-related careers) in classes across the US (N=823). Figure 1 shows that both female and non-female students have positive gains from the lesson. In addition, the overall gains from the lesson across all students are positive (Cheng et al., 2018).

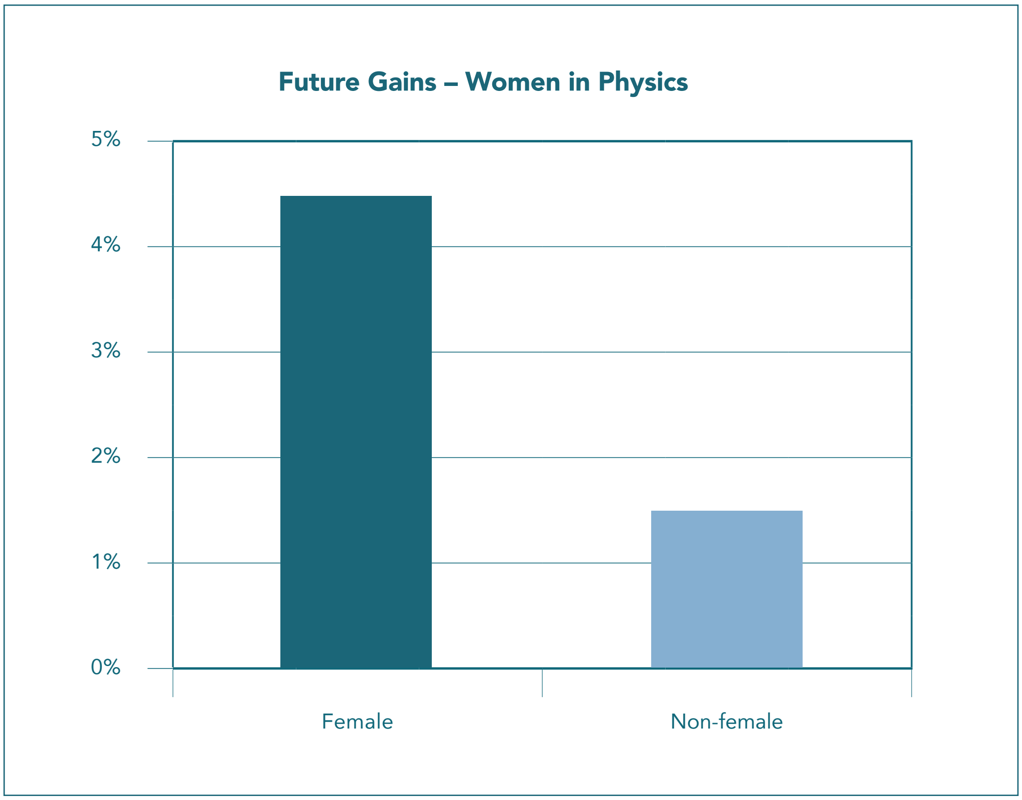


Figure 1. *Percentage gains in female and non-female students' future physics intentions (towards majoring/pursuing a career) due to the lesson.*

Teacher Motivations: Quotes about why physics teachers did the lesson.

- "We are the only way that these women are going to realize the opportunities that are available to them."
- "It shows the women in the class that it is important to you, the teacher, if you discuss these issues. That they are important to you."
- "It challenges misconceptions about what helps women."
- "I was nervous about it but then I realized how much students got out of it."

Explaining It to Students: Quotes about how physics teachers justified it to students.

- "As a white guy, these may not be things I have experienced but that doesn't mean that these things aren't important to talk about."
- "I want to hear what you, the students, think about these issues."
- "It is important to not exclude others from opportunities."
- "It is important to understand what society thinks about physics and whether these beliefs are valid."

Implementation Timing: Physics teachers who have done the lesson suggest considering these factors when deciding the optimal timing for implementation: (i) after a classroom community is established; (ii) around a time when a topic of interest to women is being covered (e.g. astronomy, light/waves, biophysics applications, alternative energy); (iii) before college applications are due (for any seniors), if possible.

LESSON PLAN: *WOMEN IN PHYSICS*

CONTENT AREA(S): Physics	TITLE: Women in Physics	
GRADE LEVEL: 11-12	DATE(S): Prior to college applications, but after a supportive classroom environment has been established	LESSON LENGTH: 60-90 minutes

OVERARCHING PURPOSE OF THE LESSON

In this lesson, students will examine the conditions for women in physics starting with an assignment and interactive presentation that draws out their prior knowledge, illustrates the current state of women in physics, and reveals implicit biases and core equity issues. The students will then engage in a discussion (drawing on evidence) about gender issues with respect to famous physicists, gendered professions, and personal experience. The purpose of the lesson is to reveal students' prior perceptions about women in physics as well as current conditions for women in physics in order to neutralize the effect of stereotypes and bias, particularly for female students.

Standard(s) Alignment: This lesson addresses NGSS 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 counter-argument based on data and evidence.

NGSS 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.
  - Scientists' backgrounds, theoretical commitments, and fields of endeavor influence the nature of their findings.
  - Science and engineering are influenced by society and society is influenced by science and engineering.

Performance Objectives

- Students will compare the challenges faced by women in physics in the past (conscious bias) to the challenges faced today (more unconscious bias).
- Students will give examples of gender inequalities with respect to science present in society today.
- Students will define unconscious bias and give one example of the effect of unconscious bias.
- Students will explain their own views on the current state of women in physics.

Critical Lesson Components:

- Ensure that a safe space is established using the Discussion Guidelines. (Body of the Lesson, Step 1)
- Ensure that students review comparative data and recognize that culture drives physics career choice. (Body of the Lesson, Step 2)
- Ensure students share their personal experiences with respect to gender and physics/science. (Body of the Lesson, Step 4)

Assessments (formative and summative)

- Students' pre-lesson essays about famous female physicists and their views about women in science today.
- Students' responses during the whole class discussion during which they share their views about famous scientists, gendered professions, and classroom experiences.
- Students' post-lesson essays about women in physics in the present day.

Materials/Resource List

- ***Women in Physics*** **Pre-Assignment** and ***Women in Physics*** **Post-Assignment** handouts (1 each per student)
- Class whiteboard, projector, computer (for teacher use for presenting ***Women in Physics*** **Slides**. (Full presentation available at STEPUPphysics.org/women).
- A document that can be projected / shared
- Pieces of paper for writing prompt activities (2 per student)
    - Or use Google Forms to allow students to anonymously share stories.
- (Optional) Devices with internet access to participate in polls

INSTRUCTIONAL PROCEDURES

INTRODUCTION: In this part of the lesson, the goal is to prime the issue of gender and get students' prior conceptions about gender issues in physics (est. time = 10 minutes)

What the Teacher Does	Anticipated Behaviors/Responses from Students
Pre-lesson: Assign students to complete the Pre-assignment prior to class. The assignment requires them to: • Recall famous physicists and conduct a Google search, then answer a few questions about what they find *(this primes gender issues given the lack of diversity that results from the search)* • Read **two** biographies. **One** of a historical physicist, choosing between Lise Meitner or Jocelyn Bell Burnell, and **one** of a modern female physicist from the list provided *(this illustrates the difficulties that women have faced and the capability of women to contribute)* • Respond to related questions	Pre-lesson: Students will complete the ***Women in Physics Pre-Assignment***.
1. ***In class:*** Share Presentation Slides (available at website; Slides 2-5; est. time = 10 minutes) Project the Google search for "famous physicist." Ask students about the physicists they found in their Google search. • What trends do they notice about the names? • In what years were women on the list active in their careers? It may be important to point out that men have been participating in physics for a long time and that even after Marie Curie, there is a lack of women on the list. (No need to discuss specific biographies; students can bring these examples up in the discussion later).	**1.** ***In class***: Students respond to what they found in their Google search. • Possible Answers: They are mostly men. They are mostly white. They are mostly of European heritage. They are mostly dead. • Possible Answers: Marie Curie lived around 100 years ago.

***BODY OF THE LESSON:** In this part of the lesson, students will engage in an interactive presentation and discussion that will allow them to make predictions, view statistics and results of studies, and discuss gender issues in physics drawing on the evidence and their own experience (est. time = 65 minutes)*	
What the Teacher Does	**Anticipated Behaviors/Responses from Students**
Interactive presentation (est. time = 65 minutes) Lead a whole class discussion organized around the slides. Think/Pair/Share can be used throughout this discussion to stimulate conversation (see Bibliography for an online resource).	
1. **CRITICAL LESSON COMPONENT:** Slide 6; est. time = 5 minutes. At the beginning of the presentation/discussion (after the Google search discussion) introduce the STEPUP Guidelines for Conduct During Discussions to students via the slide or poster (or refer to your class conduct rules if you have already established them: • **Share air time equitably.** Know yourself, balance your listening and talking. • **Value differences.** Remember that your perspective is not the only one. • **Argue using evidence.** Back what you have to say with data. • **Make sure everyone feels safe.** Safe is not the same as comfortable. • **Discomfort is OK.** Identify your learning edge and push it. • **Own your impact.** Your intentions may not be the same as your impact. These guidelines are imperative for students to feel welcome and safe enough to share. Emphasis on these guidelines is encouraged throughout the year to ensure students adequately understand their purpose and importance.	**1.** Students will read the guidelines and ask questions to ensure they understand.
2. ***Opening Slides:*** slides 6–21; est. time = 10 minutes. • **This section has two options:** Slide #11 and 12: Ask students which lines match the trend of STEM majors vs Physics majors. Slide #13-18: This is a slow reveal graph, each slide until #17 reveals one more piece of information. Ask students at each slide what they notice and wonder about the information presented. • **Regardless of the path you choose, prompt each slide with the questions in the presentation.** Encourage a few minutes of discussion on each slide, in particular regarding the role of the individual versus the role of culture and society (e.g. social norms). • In Slide 20, students are asked to suggest reasons why women are better represented in some fields than in others. Make sure to have students come up with ideas, and then the teacher can categorize these responses (for example, can have a "culture/socialization" category and a "biology/inherent traits" category).	**2.** Students might conclude that because the percentage of women in physics varies by country, the representation of women in physics is a cultural issue rather than a biological one. The included slides (with references to articles) about unconscious bias (slides 28-30 in the next section) should help students see that bias can exist even if no one is overtly sexist, but that bias can be overcome with conscious effort and training.

3. ***Physics Degree Breakdown:*** Slides 22-31; est time = 10 minutes • Students fill in a graph with their predictions of physics degrees by country, before the real graph is revealed to them • Prompt each slide with the questions in the presentation. Encourage a few minutes of discussion on each slide, in particular regarding achievement and bias • Slides 28-30 discuss unconscious bias. Remind students that this is societally determined, and can be overcome with conscious effort and training	**3.** Students may have questions about the country breakdown on slide 23. • Note that in Albania, students are assigned majors based on their performance rather than their preference. • Students might conclude that because the percentage of women in physics varies by country, the representation of women in physics is a cultural issue rather than a biological one. • This graph suggests the cause is sociocultural rather than biological. If the cause was biological, all countries would have similar percentages.
4. ***Gendered professions:*** Slides 32-34; est. time = 10 minutes. Prompts: **A.** Why do you think women appear in particular science fields more than others? **B.** What gender are your doctors and nurses? What about people you know in other technical professions (e.g. engineering)? What gender are your teachers in various subjects? **C.** What patterns have you noticed in who pursues different careers? Why do you think we see these differences? • Encourage students to notice gender disparities in any particular field and to consider why these disparities exist.	**4.** Possible responses to gendered professions: **A.** Stereotypes - Students may notice that many female scientists portrayed in the media are in fields other than physics (e.g. on the Big Bang Theory, forensic shows, medical shows). **B.** Students may notice that most engineers are men or that most nurses are women, for example. Terms indicating that a profession has a default gender may be shared, such as "male nurse" since the default gender of nurses is stereotyped to be female. **C.** 'Nature versus nurture arguments will likely emerge. Some students might say that women "naturally" gravitate to fields other than physics and engineering. Other students may believe this is due to stereotypes and other societal influences.

5. ***Personal experiences (Critical lesson component):*** slide 35; est. time = 20 minutes.
 	
• Stop and Reflect: Give students two minutes to write a first response to the prompt below, then give them time to share it with a partner.
• **Depending on the class it may be important for responses to remain anonymous.** You are the expert on the students in your classroom. If you think anonymous results will be more fruitful, we encourage you to anonymize this portion of the lesson.
• Prompt: Describe experiences you or a friend has had related to science and gender issues. Detailed questions:
  A. Who do you feel comfortable working with in class?
  B. Do you feel more comfortable in any particular class?
  C. Have you felt your abilities being questioned?
  D. Have you seen or experienced gender biases in your own life, either purposeful or unintentional?
• Next, students will have 5 minutes to write another response on a second piece of paper that they would like to share anonymously. The responses should be *related to science and gender issues.* Collect the papers, mix them up, and pass them out to be read anonymously. This structure supports discussing challenging topics.
• Some teachers have found success participating in this activity themselves. While this is not required, it can help students feel more comfortable sharing their experiences.
• Alternatively, use a Google Form to collect answers in class, then read them aloud. This can be a good way to make responses anonymous.
• As the anonymous experiences are shared, make sure to challenge sexist or racist comments that might emerge. For example, if someone comments about women's lack of ability in physics, turn to the class and ask if there is disagreement. Students will raise objections themselves. These occasions are valuable because they reveal the presence of hidden bias. Challenge statements that generalize any group since these types of statements are particularly problematic.
	5. Students will write their 1st response to the prompt on a piece of paper and then share with a partner.
	
	Then they will write a 2nd response sharing a comment, experience, etc. on a piece of paper and turn it in directly to the teacher.
	
	Possible responses include students mentioning occasions when:
	
	• someone has said something disparaging
	• others have dominated a conversation/activity
	• they have been made to feel stupid
	• they prefer the environment in certain classes over others
	• they prefer working with people of certain genders more than others
	• they heard about experiences from friends or family
	• "women just aren't interested in science"
	• no experience of gender issues at all

6. ***Career Influences:*** slide 36; est. time = 10 minutes. • Ask students: Do you think societal beliefs related to gender have any influence on the career you want to pursue? Or on careers you would not consider? ***General tips for class discussion*** • Encourage students to disagree constructively (e.g. with evidence or argumentation). • If the students aren't challenging each other, encourage them to, or jump in yourself (e.g. if students mention women's disinterest in physics being biological, ask why the same trends are not seen in all countries). • Always encourage students to think about WHY gender disparities exist. At some point, a 'nature vs. nurture' discussion is likely to arise. Students need to become aware of the sociocultural pressures impacting their individual decisions.	**6.** Students will voluntarily share viewpoints and experiences and be responded to by other students.

LESSON CLOSURE: In this part of the lesson, students will come up with strategies to support diversity in physics and will be encouraged to enact the best strategies proposed (est. time = 10 minutes)

What the Teacher Does	Anticipated Behaviors/Responses from Students
1. ***Proposing strategies:*** slide 37; est. time = 5 minutes. • Ask students to write a response to the prompts on a piece of paper to be shared anonymously. Collect the papers, mix them up, and pass them out. • Prompt: What can be done to support diversity in physics? What could you do? What could you do as a physics class community to support one another?	**1.** Students will write their ideas about how to support diversity in physics, and how to support one another in class.
2. ***Discussion:*** est. time = 5 minutes. • Ask for a volunteer to share what is written on their paper. Write the strategy in a Google Doc (or other projected digital document) or on the board. Poll the class to see how many other students have similar responses on their paper. Do this until there are no new strategies proposed. • Assess and comment on strategies that will not be supportive or that have unintended consequences, e.g. offering to help struggling women in the class might not be supportive since it undermines women's capabilities. • Be sure to distinguish between what can be done inside vs outside of the classroom. Students should be committing to change in both locations. • When you have the compiled list, say to the students, "This is our commitment to change." Share the document with your students, ideally in a digital form. • Slide 38 includes a summary • Slides 39 has a community commitment	**2.** Students will volunteer to share ideas from the anonymous paper they have. Possible responses from students include the following: • *Supporting diversity is not important (suggested counterpoints in this situation are: (1) Diverse teams produce better results. This is supported by research on teamwork; (2) Our current STEM workforce is insufficient. If we do not actively recruit women, we could be missing out on half of the potential workforce.)* • *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* • *Giving help to women who are struggling in class (Note the counterpoint that this could undermine women's capabilities if you think they always need help.)*
3. ***Post-Lesson:*** Assign students to complete the ***Women in Physics* Post-Assignment**.	**3.** Students complete assignment, sharing their views after the class discussion.

ACCOMMODATIONS & EXTENSIONS

Accommodations

- English Language Learners: Allow extra time for ELL students to complete written responses to prompts, allow extra time for ELL students to formulate their responses prior and during discussions, pair them with a student who knows their native language and/or is willing to help, allow the usage of a device for them to translate
- Students with Disabilities: Depending on the disability, limit the need to move around the classroom during the writing prompt exchange, situate students where they can clearly see/hear slides and discussions, and allow extra time as necessary.

Potential tech enhancements for live visualization of student responses

- spsedtech.wordpress.com/2013/08/24/socrative-and-wordle-on-day-one-getting-to-know-your-students/ - This article describes how to use Socrative and Wordle to make a word cloud, which could be used to visualize the physicists students can remember as part of the pre-class assignment.
- polleverywhere.com - Poll everywhere can automatically make word clouds from open-ended questions, which can also be used to poll students about what physicists they remember. Poll everywhere can also be used to poll the class on presentation questions. Free versions of Poll Everywhere are available as well.
- mentimeter.com - Mentimeter can also be used to create visualizations of students' responses
- Remote adaptations will be made available at STEPUPphysics.org/women, including a prototype website to support response to discussion prompts remotely.

Curriculum enhancements (additional lessons on underrepresentation)

- Teachers interested in additional lessons and resources on underrepresentation in physics, including issues of race and ethnicity, can implement curriculum from the The Underrepresentation Curriculum (underrep.com)

Online Community Discussions

- Teachers have also shared their adaptations at the STEP UP online community. Register at STEPUPphysics.org to join the conversation.

BIBLIOGRAPHY

- Next Generation Science Standards – Appendix F on Science and Engineering Practices. Retrieved from: www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf
- Next Generation Science Standards – Appendix H on the Nature of Science. Retrieved from: 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://whyy.org/articles/lise-meitner-the-forgotten-woman-of-nuclear-physics-who-deserved-a-nobel-prize/ or https://www.unsw.edu.au/science/about-us/equity-diversity-inclusion/science-history-trail/lise-meitner. Feel free to read and decide which you think will resonate better with students.
- Jocelyn Bell Burnell: biography.com/people/jocelyn-bell-burnell-9206018

THINK-PAIR-SHARE RESOURCE

- theteachertoolkit.com/index.php/tool/think-pair-share

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/african-americans-earning-bachelors-physical-science-and-engineering-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:

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

Women in Physics Pre-Assignment

Name: ______________________ **Date:** ______________

Google search:

1. Before doing the Google search below, **write the names** of any physicists you can think of (be honest - don't cheat and look them up beforehand).
2. Google "famous physicist." **Write down the names** of the first five physicists you found.
3. How many **years ago** did the earliest physicist on the list live?
4. How many **women** appear on the list?

Read two biographies, as follows:

- Lise Meitner article (https://whyy.org/articles/lise-meitner-the-forgotten-woman-of-nuclear-physics-who-deserved-a-nobel-prize/) or https://www.unsw.edu.au/science/about-us/equity-diversity-inclusion/science-history-trail/lise-meitner. Feel free to read and decide which you think will resonate better with students.
- One of the following scientist profiles: Claudia Alexander, Deborah Berebichez, Ellen Ochoa, or Shirley Ann Jackson (aps.org/careers/physicists/profiles)

Respond to the following questions on the women from the two biographies:

What are the contributions made by these women? Summarize your response in your own words in a few sentences. Look up anything you don't understand!

What obstacles did the women overcome in their career paths?

In your view, is the opportunity to excel in physics any easier for women now than it was in the 20th century? Explain how, including what is easier and what is unchanged.

Women in Physics Post-Assignment

Name: ______________________ **Date:** ______________

Respond to the following questions by crafting at least a paragraph for each section:

Based on the class discussion, do you believe society discourages (subtly or obviously) women from becoming interested in physics careers? Why or why not? If so, what do you think could be done to reduce the effect of discouragement?

In what ways do you think societal beliefs about gender have influenced your career interests? Does this influence bother you? Why or why not?