Careers in Physics

LESSON PLAN
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Help students **assess their personal values** in relation to a career in physics, **examine profiles** of professionals with physics degrees, and **envision themselves** in a physics career.

1. Students brainstorm careers that one can have with a physics degree.

3. Using data from their surveys and a matrix, students are matched to relevant physicist profiles to research and discuss.

5. Students complete a personal career profile in which they envision themselves as a future physicist.

2. Students complete a brief survey to determine areas of interest for their future careers.

4. Students discuss new careers in physics they learned about, and reflect on how their perceptions of careers in physics have changed.

6. Students discuss data presented by the teacher on careers and salaries in physics.

Learn more at [STEPUPphysics.org](http://STEPUPphysics.org) and register to access instructional support & FAQs
Lesson Topic: In this lesson, students will explore profiles of individuals with a degree in physics and identify goals that can be accomplished with a physics degree. They will also create their own future career profiles. The goal of the lesson is to help students realize the breadth of careers available with a physics degree and envision how a physics degree would help accomplish many goals.

Lesson Evidence: This lesson has been shown to improve students’ future physics intentions (e.g. majoring in physics in college or 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).

Teacher Motivations: Quotes about why physics teachers did the lesson.
- “Students don’t realize all the things they can do with a physics degree.”
- “It helps students see that physicists can help the world and work with others.”
- “As a student, I wish I had the opportunity of envisioning my future with physics.”
- “The posters students make as part of the lesson helps recognize students and who they are.”

Implementation Timing: Physics teachers suggested the optimal timing for implementation is before college applications are due.
OVERARCHING PURPOSE OF THE LESSON

In this lesson, students will assess their values in relation to their future education and career goals and match themselves with profiles of physicists who have pursued a variety of careers supported by their studies in physics. Students will examine the profiles to identify transferable traits and skills that can be obtained via a physics degree and then create their own career profiles with a focus on how earning a physics degree can help them achieve their career goals.

Standard(s) Alignment: This lesson addresses NGSS Appendix H – Understandings about 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.

- **Scientific Investigations Use a Variety of Methods**
  - Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Performance Objectives

- Students will examine profiles of physicists and identify skills and traits developed by earning a degree in physics.
- Students will identify ways that a degree in physics can support a variety of careers.
- Students will create a personal profile in which they identify how physics can help them meet their career goals.

Assessments (formative and summative)

- Students’ responses during class discussions of physicists’ profiles
- Students’ responses to the Career Goals Pre-Survey (Appendix 1)
- Personal Career Profile (Appendix 4 – Parts 1 and 2)

Materials/Resource List

- Sticky notes of different colors (6 per student - 3 notes in 2 different colors)
- Career Goals Pre-Survey and Personal Career Profile (1 per student) (Appendix 1 and Appendix 4)
- Profile Matching Matrix (1 each per student) (Appendix 2)
- Devices with internet to access physicists’ profiles. Alternatively, Physicists Career Profiles can be printed in advance of the lesson (Appendix 3, or modifiable Word document version available). Print 2-3 of each profile.
- Devices with internet access to research career choices
- Class whiteboard, projector, computer (for teacher use in discussion and presentation of Physics Careers and Salaries Presentation, see Appendix 5 which shows slide thumbnails. Full presentation available at STEPUPphysics.org.

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 sticky note activity, situate students where they can clearly see/hear slides and discussions, and allow extra time as necessary.
INSTRUCTIONAL PROCEDURES

**INSTRUCTION: Reveal students’ prior conceptions about the types of careers people who earn a bachelor’s in physics can have and have students make a visual representation that can be revisited by the end of the lesson. (est. time = 10 minutes)**

<table>
<thead>
<tr>
<th>What the Teacher Does</th>
<th>Anticipated Behaviors/Responses from Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day of lesson, in class</strong></td>
<td><strong>In class</strong></td>
</tr>
</tbody>
</table>
| 1. Give each student 3 sticky notes (of the same color). Ask students to write down a response to the following prompt: “On each sticky note, name a career you can have with a physics bachelor’s degree.” | 1. Students will record their responses on the sticky notes. Possible answers:  
  - Scientist, physicist, engineer, lab technician, physics teacher, researcher, doctor, etc. |
| 2. Have students post their sticky notes in a designated section of the room grouping them by common careers listed (i.e., medicine/health, laboratory/research, business/finance, education/academia). Make note of trends. | 2. Students will post sticky notes in a designated section of the room sorting them by common careers. |
| 3. Open the lesson with a discussion of what physicists do (Note: definition of a physicist for this lesson is a person with a bachelor’s degree or higher in physics): “We’re going to define a physicist as someone with a bachelor’s degree in physics. With that in mind…”  
   A. Who do you think physicists work with?  
   B. Who is helped by or benefits from the work of physicists?  
   C. What societal outcomes do physicists address in their careers?  
   D. What traits/skills do you think physicists have that they apply in their careers?  
   Now we’re going to look at profiles of physicists to see how getting a bachelor’s degree in physics helped them in their careers.” | 3. Students will contribute to discussion - consider using randomized calling methods such as rolling dice, popsicle sticks or playing cards.  
   Accept all responses to get at students’ prior conceptions. Possible answers to prompts:  
   A. Physicists work with other scientists/engineers/physicists. Some work on their own. Some work with students (educators). Some work with nonscientists.  
   B. Physics helps everyone. Other scientists benefit by getting new knowledge. No one benefits because they work on topics that aren’t practical/applicable to real-life.  
   C. Their work helps engineers and eventually it gets to help society at large.  
   D. Physicists have the following traits/skills: smart/logical, good at math, good at solving problems, good at using instruments/machines, ability to communicate, ability to work with others, and creativity. |

**BODY OF THE LESSON: In this part of the lesson students will examine physicists’ career profiles to learn about the skills that can be gained through a physics degree. They will learn about the wide variety of possible careers and skills to be gained from a physics degree through discussion with a peer and then the whole class. They will revisit the sticky note activity to explore how their conceptions have changed after reviewing the profiles. They will then be assigned to make their own profiles of themselves in the future after having earned a physics degree. (est. time = 40 minutes)**

<table>
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<tr>
<th>What the Teacher Does</th>
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<tbody>
<tr>
<td>1. Hand out the <a href="#">Career Goals Pre-Survey</a> (Appendix 1) and have students complete it. When they are finished (about 2 min), hand students the <a href="#">Profile Matching Matrix</a> (Appendix 2) and have each find their matching profile(s). This needs to be ready before commencing the bulk of the lesson.</td>
<td>1. Students will complete the <a href="#">Career Goals Pre-Survey</a> (Appendix 1) and find their matching profiles.</td>
</tr>
</tbody>
</table>
2. Distribute copies of **Physicists Career Profiles** to students (Appendix 3) or direct them to the profiles they need to explore on the profile website/handouts. They can also search the internet for more information about the profiled physicist. If students are not interested in the profile they are matched with, allow them to choose another one that interests them. Direct students to pick up another profile if their first choice runs out.

   Have students read the profile and consider the following questions while reading their profile:
   - What is the career of the physicist in your profile?
   - What does your physicist personally value about his/her degree/career?
   - Who benefits from the work your physicist does? How does this physicist's work contribute to society?
   - What skills did your physicist gain from earning their degree in physics? How did these skills help your physicist in achieving their career?

3. After students review their assigned profile, ask them to pair with another student in the class to share their profile and their responses to the questions.

4. Distribute new sticky notes (3 per student in a different color). In a whole class discussion, have students share their chosen examples. Ask them to write 3 new careers on the sticky notes that they hear about or share with the class themselves during the discussion. Facilitate a discussion on goals and career outcomes that a physics education achieves. As each student shares, focus on having new information shared with the class.

   **Prompts:**
   - **A.** What new careers emerged from researching the physicist profiles? Write them on your sticky notes.
   - **B.** What surprised you about your profile?
   - **C.** What values and goals do you believe drive these physicists in their careers?
   - **D.** How do you think these physicists contribute to society and help the world?
   - **E.** Who do you think benefits from the work of these physicists?
   - **F.** Can you infer what skills allowed them to accomplish what they did in their career?

   **Possible student responses, see responses to discussion prompts below:**

   - **A.** A person with a physics degree can be a film producer, actuary, science writer, YouTuber, cardiologist, policy analyst, medical physicist, biophysics technician, laser scientist, teacher, etc.
   - **B.** It surprised me how normal the physicist was; most physicists are not like the Big Bang Theory physicists.
   - **C.** Values: Physicists are driven by being able to contribute to larger causes/pursuits, being able to help others, being able to work with others, independence/freedom/flexibility to pursue interests/passions, being able to work in a wide variety of areas, being able to work on challenging problems.
   - **D.** Contributions: Physicists address many societal goals like educating the public about science, protecting the environment, protecting human health, entertaining, and building the economy.
   - **E.** Beneficiaries: Physicists can benefit everyone, other scientists, the companies physicists work for, and the specific group they serve in their career (ex: patients for those in medical field).
   - **F.** Possible skills/traits: Physicists use skills like scientific reasoning; problem solving; creative, critical, analytical, and quantitative thinking; and have the ability to collaborate with others, communicate through writing and speaking, and do mathematical modeling.
5. Allow students to post the new sticky notes in the designated location (grouping them by common careers). This should provide a visual representation of the breadth of careers pursued by individuals with a bachelor’s in physics. Compare and contrast with the sticky notes from the start of class. Emphasize that careers in physics include professions that benefit humans, society, and the Earth.

5. Students will post the new sticky notes in the designated location (grouping them by common careers). Possible responses:
   - Anticipate that responses will be expanded to include the careers profiled in the lesson, but they may still include the original examples (ex: scientist).

6. Critical component of lesson: creating Personal Career Profiles. Ask students to identify a career that they have an interest in. Challenge them to incorporate a physics degree into the pathway to their chosen career. What would their profile look like? The students will be creatively imagining their futures with a physics degree. This may be somewhat contrived, but this is an essential component of the lesson, especially Part 2 of the profile. It allows students to consider the possibility of a physics degree in a more serious way. If there is a high likelihood that it will not be completed at home, then it is recommended that you set aside class time for this activity.

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6. Students will imagine their own careers and think of ways a physics degree can help. It is recommended that students type out their Personal Career Profiles (prior work has found that students will write more in-depth profiles when they type them out.)

7. Distribute Personal Career Profile (Appendix 4). Part 1 can be used as scaffolding to Part 2 if necessary. Part 2 can be completed at home. Make it clear that Part 2 of the profile will be posted in class so students should make it professional and presentable. You may want to make a profile of yourself to share with the class as well.

7. Students will fill out Part 1 of the Personal Career Profile (Appendix 4) in class. Students complete Part 2 (this can also be done at home). It is expected that not all students will have a clear idea of pathways to their chosen career. Suggested websites for students to use in their career exploration are listed in the bibliography.

8. When students have completed Part 2 of the career profile, ask them to share their profiles with a peer. After collecting the profiles, post them in the classroom. Have students make their profile into a poster on cardstock or poster board to make it sturdier for display.

8. Students will share their profiles in pairs.

LESSON CLOSURE: In this part of the lesson the teacher will present information about the advantages of pursuing a physics degree at the bachelor’s level and how it benefits career prospects in a variety of ways. They will then reflect on any surprising aspects of the lesson through a brief writing exercise. (est. time = 10–15 minutes)

<table>
<thead>
<tr>
<th>What the Teacher Does</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Give a brief presentation on Physics Careers and Salaries Presentation (Appendix 5; slides available for download at STEPUPphysics.org).</td>
<td>1. Students will listen to the presentation and respond to any embedded questions in the presentation.</td>
</tr>
<tr>
<td>2. Have students complete an exit slip reflection at the end of the presentation (last slide).</td>
<td>2. Students will write their responses to the exit ticket questions at the end of the presentation.</td>
</tr>
</tbody>
</table>
EXTENSIONS

Potential tech enhancements to activities

- spsedtech.wordpress.com/2013/08/24/socrative-and-worddle-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 in place of the sticky note activities in the lesson
- polleverywhere.com - Poll Everywhere can automatically make word cloud from open-ended questions, which can be used in place of the sticky note activities in the lesson.

Additional activities/extensions

- classtools.net - This site has simulators that can be used to enhance the lesson such as a headline generator, Facebook profiles (Facebook mimic), Twister (Twitter mimic), SMS generator (mimic text message exchange), that could be used to extend the personal profile creation component or enhance the lesson.

BIBLIOGRAPHY


CAREER EXPLORATION WEBSITES:
aps.org/careers
careersinphysics.org/facts.cfm
spsnational.org/careerstoolbox
aapt.org/resources/Herstories.cfm
www.physics.org/careers.asp?contentid=381
careeronestop.org/ExploreCareers/explore-careers.aspx
ncdla.org/aws/NCDX/pr/sp/resources
Q1. Mark the three most important factors for your future career satisfaction:

- a. Making money
- b. Helping other people
- c. Having job security
- d. Working with people
- e. Having lots of family time
- f. Having an exciting job
- g. Making use of my talents/abilities

Q2. Mark two areas you are most interested in:

- a. Medicine/Health
- b. Biology
- c. Chemistry
- d. Physics
- e. Astronomy
- f. Engineering
- g. English/Writing
- h. Finance/Business/Consultancy
- i. Administration/Management
- j. Arts/Media
- k. Academia/Education
After completing the Career Goals Pre-Survey, find which career profiles best fit your response using the table below. See next page for instructions.

<table>
<thead>
<tr>
<th>Q2</th>
<th>PROFILES</th>
<th>Q1</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Christina Barrow - Medical Physicist</td>
<td>✔</td>
</tr>
<tr>
<td>a</td>
<td>Albin Gonzalez - Medical Physicist</td>
<td>✔</td>
</tr>
<tr>
<td>a</td>
<td>Urszula Tajchman - Pediatric Cardiologist</td>
<td>✔</td>
</tr>
<tr>
<td>b</td>
<td>Allison Porter - Biophysics Technician</td>
<td>✔</td>
</tr>
<tr>
<td>c</td>
<td>Alice White - Materials Scientist</td>
<td>✔</td>
</tr>
<tr>
<td>d</td>
<td>Alison Binkowski - Health Policy Analyst</td>
<td>✔</td>
</tr>
<tr>
<td>d</td>
<td>Nasya Eassa - Nano-particle Physicist</td>
<td>✔</td>
</tr>
<tr>
<td>d</td>
<td>Kate Shaw - Experimental Particle Physicist</td>
<td>✔</td>
</tr>
<tr>
<td>d</td>
<td>Nadya Mason - Materials Physics Professor</td>
<td>✔</td>
</tr>
<tr>
<td>e</td>
<td>Kelle Cruz - Astrophysicist</td>
<td>✔</td>
</tr>
<tr>
<td>e</td>
<td>Gabriela Gonzalez - Astrophysicist</td>
<td>✔</td>
</tr>
<tr>
<td>e</td>
<td>Sara Seager - Astronomer and Planetary Scientist</td>
<td>✔</td>
</tr>
<tr>
<td>f</td>
<td>Jessica Barrios - Structural Engineering</td>
<td>✔</td>
</tr>
<tr>
<td>f</td>
<td>Paul Davis - Applications Engineer</td>
<td>✔</td>
</tr>
<tr>
<td>f</td>
<td>David Sullivan - Engineer</td>
<td>✔</td>
</tr>
<tr>
<td>f</td>
<td>Aaron Weiss - Prototype Engineer</td>
<td>✔</td>
</tr>
<tr>
<td>g</td>
<td>Mark Alpert - Magazine Editor</td>
<td>✔</td>
</tr>
<tr>
<td>g</td>
<td>Liz Kruesi - Freelance Science Writer</td>
<td>✔</td>
</tr>
<tr>
<td>g</td>
<td>Kate McAlpine - Freelance Writer</td>
<td>✔</td>
</tr>
<tr>
<td>h</td>
<td>Deborah Berebichez - Financial Risk Analyst</td>
<td>✔</td>
</tr>
<tr>
<td>h</td>
<td>Amanda Joy McDonald - Actuary</td>
<td>✔</td>
</tr>
<tr>
<td>h</td>
<td>Deborah Moore – Environmental Consultant</td>
<td>✔</td>
</tr>
<tr>
<td>h</td>
<td>Maggie Seeds - Associate Consultant</td>
<td>✔</td>
</tr>
<tr>
<td>i</td>
<td>Ginger Kerrick - NASA Flight Director</td>
<td>✔</td>
</tr>
<tr>
<td>j</td>
<td>Dianna Cowern - YouTuber</td>
<td>✔</td>
</tr>
<tr>
<td>j</td>
<td>Laura Kasian - Production Technician/Software Engineer</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Summer Ash - Director of Outreach</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Katherine Freese - Physics Professor</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Evelyn Hammonds – History of Science Professor</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Yung Tae Kim - Skateboarding Physicist &amp; Educator</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Mary Lee McJimsey - High School Physics Teacher</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Marta Dark McNeese - Laser Science Professor</td>
<td>✔</td>
</tr>
<tr>
<td>k</td>
<td>Carlane Pittman - Director for Outreach</td>
<td>✔</td>
</tr>
</tbody>
</table>
HOW TO USE THE TABLE

Step One

Look at responses to Question 2 (Q2, left-most column) and mark the rows that match your response.

**EXAMPLE:** Sally chooses e (Astronomy) and j (Arts/Media) for Q2. She then goes to the table and sees three choices for Q2e and two for Q2j. Once she highlights/circles the responses she moves on to the next step.

<table>
<thead>
<tr>
<th>Q2</th>
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</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>Kelle Cruz - Astrophysicist</td>
<td>✔   ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>e</td>
<td>Gabriela Gonzalez - Astrophysicist</td>
<td>✔   ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>e</td>
<td>Sara Seager - Astronomer and Planetary Scientist</td>
<td>✔   ✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>j</td>
<td>Dianna Cowern - YouTuber</td>
<td>✔   ✔ ✔ ✔ ✔  ✔</td>
</tr>
<tr>
<td>j</td>
<td>Laura Kasian - Production Technician/Software Engineer</td>
<td>✔   ✔ ✔ ✔ ✔  ✔</td>
</tr>
</tbody>
</table>

Step Two

From the groups marked in Step One, mark the columns noting the answers chosen for Question 1 (Q1, columns on the right) noting that ✔ indicates recommended profiles to read and “ - ” denotes a less relevant profile to read.

**EXAMPLE:** For Q1, Sally picks b (helping other people), d (working with people), and e (having lots of family time). She then goes to the table and highlights or circles down the column matching her responses, taking note of every one that has a ✔.

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</tr>
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<td>j</td>
<td>Laura Kasian - Production Technician/Software Engineer</td>
<td>✔   ✔ ✔ ✔ ✔  ✔</td>
</tr>
</tbody>
</table>

Step Three

Once all the responses have been marked, tally up all the ✔ marks for each profile (across the row). The one which has the highest number of ✔ marks is the profile that is most recommended to read. If there are tied highest results, you may choose between any of those profiles to read.

**EXAMPLE:** Sally highlights/circles her choices in yellow and sees that two profiles have the same number of ✔ marks. She then reads the job title of the profiles that have tied with the highest number of ✔ marks and chooses the one she finds most interesting.
Physicists Career Profiles

Mark Alpert - Magazine Editor
A lifelong science geek, Mark Alpert majored in astrophysics at Princeton University and wrote his undergraduate thesis on the application of the theory of relativity to Flatland, a hypothetical universe with only two spatial dimensions. (The resulting paper was published in the journal General Relativity and Gravitation and has been cited in more than 100 scholarly articles.) After Princeton, Alpert entered the creative writing program at Columbia University, where he earned an M.F.A. in poetry in 1984. He started his journalism career as a small-town reporter for the Claremont (N.H.) Eagle Times, then moved on to the Montgomery (Ala.) Advertiser. Having lots of family time, Alpert is very close to his wife and two non-robotic teenagers. He’s a proud member of Scientific American’s softball team, the Big Bangers.

Summer Ash - Director of Outreach
Summer Ash is the Director of Outreach for Columbia University’s Department of Astronomy where she has been based since 2008. She spent her first three and a half years teaching as a Science Fellow on Frontiers of Science in Columbia’s Core Curriculum before transitioning to public outreach for the last five. As a self-professed space cadet, Summer grew up dragging friends and family out at all hours of the day or night to look up at the sky. She earned a bachelor’s degree in mechanical engineering from Stanford University and a master’s in space studies from the International Space University and worked as an aerospace engineer on the X-34 Program at Orbital Sciences Corporation (now Orbital ATK) before making the jump from low-earth orbit to intergalactic scales. Summer did five years of graduate research at the University of Cambridge on the evolution of radio galaxies and the effect of active galactic nuclei (a.k.a. AGN or supermassive black holes) on galaxies and galaxy clusters. Consequently, she will work AGN into everyday conversation whenever possible. Having been both a rocket scientist and a radio astronomer, she’s now harnessing her powers for science communication and to advocate for equity and inclusion across all STEM fields.

Jessica Barrios - Structural Engineer
Jessica Barrios was inspired to pursue engineering by her father, who is a professional petroleum engineer. “For as long as I can remember, I’ve enjoyed science, problem solving and building structures out of any material available,” she says. Authentic and hardworking, Jessica enjoys tackling the different challenges unique to each project, “challenges that keep you on your toes no matter how much experience you have.” She also likes seeing each project go “from drawings on paper to a tangible structure everyone can see, and seeing it safely used for its purpose.” She was attracted to CE Solutions in 2016 because the growing company allows her to grow, too, within its distinctive culture. Jessica is a self-proclaimed “sports junkie,” whether it’s practicing, watching or simply talking about athletics. She also likes to watch movies, cook, and spend time with family.

Christina Barrow - Medical Physicist
Christina Barrow was interested in math and science from an early age, entering her first science fair as a second grader. “I was always tinkering around the house as a child, trying to figure out how and why things worked the way they did,” she says. After finishing her undergraduate degree, Christina worked in server development at Dell Computer Corporation for three years and then went on to accept a position in the biomedical engineering field. At this point in her career, Christina realized that she wanted to use her science background to make a contribution to the medical field and work in patient care. She pursued graduate school in Medical Physics, a field that combined her love for modern medicine, math, and physics.
Deborah Berebichez - Financial Risk Analyst

Growing up in Mexico City, Mexico, Debbie Berebichez was filled with a natural curiosity about the world and dreamed of being an astronaut. Unfortunately, she grew up in a conservative community that strongly discouraged girls from pursuing careers in science. So, Debbie let go of dreams of science and focused on more socially acceptable pursuits, such as theatre and writing. Debbie continued to work hard in school however and received a scholarship to study philosophy in the US at Brandeis University. Part of her coursework included an intro-level astronomy course, which she immediately fell in love with. She successfully caught up with the needed physics coursework and was able to finish her physics degree before her scholarship ended.

After becoming the first Mexican woman to graduate from Stanford University with a physics Ph.D., and completing two postdoctoral research positions, Debbie decided that she wanted a life outside of academia and research. She took her smarts to Wall Street and became a quantitative risk analyst. Now, as Vice President of Risk Analytics at Morgan Stanley, Debbie uses math models and quantitative analysis, like in statistics, to determine and manage the financial risk of investments. She trains her clients to use these math models, customizing solutions for their needs, creating mathematical models that will assess the risk of investments worth millions.

[aps.org/careers/physicists/profiles/berebichez.cfm](aps.org/careers/physicists/profiles/berebichez.cfm)

Alison Binkowski - Health Policy Analyst

Alison Binkowski has had what many people would consider a “non-traditional” physics career. Her passion always drew her toward international health care issues, and some of her personal experiences helped form her concern. “I thought I wanted to work in... international health,” she says, “but after a summer in Senegal and Mali with the UN where I ended up being hospitalized in Mali for a week, making use of my talents/abilities I became more cognizant of the advantages of working on domestic health issues.” Alison believes that her background in physics and computer science has served her well throughout her work. “Many fields – including international development and health policy – need more people with strong analytic backgrounds.” For this reason, her training was considered an asset by her academic institutions. “My analytic training was noted as a primary reason why I was offered a partial academic scholarship in graduate school, and what helped me stand out from other candidates to get my current job at the [Government Accountability Office].” Alison says that she was drawn to physics because she “was always interested in how the world worked: from why objects fall to what was at the ‘edge’ of the universe. I also found the fact that phenomena could be captured and explained by mathematical formulas elegant, appealing, and even a bit spiritual.”

[careersinphysics.org/physicists/Detail.cfm?id=2855](careersinphysics.org/physicists/Detail.cfm?id=2855)

Dianna Cowern - YouTuber

Dianna Cowern is the creator of the award-winning YouTube channel Physics Girl, an educational series with PBS Digital Studios. She has reached over one million subscribers with 130+ videos on topics like, “How to create a vortex in your pool,” and “Why is the universe flat?” Through Physics Girl, public talks, and private workshops for teachers across the nation, Dianna explains exciting science topics, inspires kids—especially young girls—to pursue an interest in science, and rallies the general public to think critically through the wonder of science. Surprise cameos from Bill Nye, skateboard legend Rodney Mullen, and Anne Wojcicki (23andMe) have helped the channel receive over 78 million views. Before starting Physics Girl, this Hawaii-raised MIT physics alumna completed a post-baccalaureate fellowship in astrophysics at Harvard, then worked as a software engineer at General Electric, and as UCSD’s physics outreach coordinator. Physics Girl has been featured on the Huffington Post, Slate Magazine, Scientific American blogs, and Popular Science.

Lesson Plan: Careers in Physics

**Paul Davis - Applications Engineer**

Paul Davis earned his BS in Physics at Howard University. He is employed through Corning, Inc and works on a team of engineers who support a major customer that uses Corning optical fiber to manufacture fiber optic cable. This industrial job allows him to contribute to the development of important products for the company and their clients. Paul's advice for students looking to follow on a similar path is to build a network with other students and professionals as “this can open doors.” He also encourages asking lots of questions of this network and the world to stay curious and constantly learning. Paul also suggests that aspiring engineers join technical organizations and to make sure you “don’t stay in a job that isn’t meeting your needs.”

[spsnational.org/career-resources/physicist-profiles/paul-davis](https://spsnational.org/career-resources/physicist-profiles/paul-davis)

**Kelle Cruz - Astrophysicist**

Kelle Cruz studies a kind of celestial body called brown dwarfs to better understand planets outside our solar system. She is an assistant professor at Hunter College in New York, where she continues her work on brown dwarfs. Kelle loves the independence that her degree in physics has given her. She gets to pick her activities based on personal choice and interests. She enjoys the freedom of essentially being her own boss and having a lot of free rein in her work. “I decided early on that I never wanted to make money by making other people money and my physics degree has enabled me to accomplish that goal,” she says. She is currently serving on the Board of the American Astronomical Society. Prior to being elected to the Board, she served as the Chair of the Committee on Employment from 2010-2017. She is the founder and Editor-in-Chief of the AstroBetter blog and wiki and is on the Coordination Committee of the Astropy Project where she promotes information-sharing practices among astronomers. She also started ScienceBetter Consulting, a small business dedicated to serving the needs of the scientific community.

[aps.org/careers/physicists/profiles/cruz.cfm](https://aps.org/careers/physicists/profiles/cruz.cfm)

**Nashwa Eassa - Nanoparticle Physicist**

Nashwa Eassa has a Master of Science in Material Physics and Nanotechnology and is pursuing a Postdoctoral fellowship in nano-photonics. She founded Sudanese Women in Science, an organization dedicated to “increasing effectiveness and participation of Sudanese women in science and technology at all levels and to enforce the role of women in development.” In Sudan, more women pursue sciences in higher education institutions than men, however, there are very few women scientists involved in leadership. Nashwa won the Elsevier Foundation Award for Early Career Women Scientists in the Developing World in 2015 for her research in nanoparticle physics. She is also an assistant professor of physics at Al Neelain University - Khartoum and is currently collaborating on a project that aims at sanitizing water through solar radiation.


**Katherine Freese - Physics Professor**

Katherine Freese is the George E. Uhlenbeck Professor of Physics at the University of Michigan. She has contributed to early research on dark matter and dark energy and was one of the first to propose ways to discover dark matter. Her idea of indirect detection in the Earth is being pursued by the IceCube Neutrino Observatory experiment, and the “wind” of dark matter particles felt as the Earth orbits the Milky Way (work with David Spergel) is being searched for in worldwide experiments. Recently she proposed a new theoretical type of star, called a dark star, powered by dark matter annihilation rather than fusion. Freese has also worked on the beginnings of the universe, including the search for a successful inflationary theory to kick off the Big Bang, and she has studied the ultimate fate of the universe, including the fate of life in the universe. Her hope for the future of humanity is based on the fact that “humans are very smart. We can think not only of solutions to problems but also are capable of remarkable insights and inventions. The same drive that pushes us to explore our Earth, to head into space, and to think about the Cosmos, has given us the brainpower to survive and I hope it always will.” She wrote a book called “The Cosmic Cocktail: Three Parts Dark Matter” and has made appearances on TV, including BBC and Discovery Channel.

[en.wikipedia.org/wiki/Katherine_Freese](https://en.wikipedia.org/wiki/Katherine_Freese)
Gabriela Gonzalez - Astrophysicist

When asked about her love for physics, Gabriela Gonzalez said, “I was amazed at how we could ‘explain’ the world with physics and we could predict what objects would do. When I found out this also applied to stars and the universe, and that there were unknown phenomena waiting to be discovered, I decided I couldn’t do anything else!” She is currently a professor in the physics and astronomy department at Louisiana State University (LSU). In addition to teaching, she works with the nearby Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, Louisiana.

Evelynn Hammonds - History of Science Professor

Professor Hammonds is the Barbara Gutmann Rosenkrantz Professor of the History of Science and Professor of African and African American Studies and current chair of the Department of the History of Science at Harvard University. From 2008–2013 she served as Dean of Harvard College. Professor Hammonds’ areas of research include the histories of science, medicine and public health in the United States; race and gender in science studies; feminist theory and African American history. Her current work focuses on the intersection of scientific, medical and socio-political concepts of race in the United States. Professor Hammonds earned a Ph.D. in the history of science from Harvard University, a S.M. in physics from the Massachusetts Institute of Technology (MIT), a B.E.E. in electrical engineering from the Georgia Institute of Technology, and a B.S. in physics from Spelman College. In 2010 she was appointed to President Barack Obama’s Board of Advisors on Historically Black Colleges and Universities and in 2014 to the President’s Advisory Committee on Excellence in Higher Education for African Americans. She is currently director of the Project on Race & Gender in Science & Medicine at the Hutchins Center for African and African American Research at Harvard.

Laura Kasian - Production Technician/Software Engineer

Music is blaring in a downtown nightclub closed for a private party. Screens mounted around the venue run a movie trailer and a credits list, attracting small crowds that drift up to point out names. Beside the dance floor is a photo booth and a table loaded with props. It’s the wrap party for Hotel Transylvania 2, an unexpected place to find someone with a Ph.D. in astronomy. Laura Kasian is a physicist who puts her analytical skills to use in visual effects at Sony Pictures Imageworks in Vancouver, Canada. Working on everything from the gritty Suicide Squad to the animated movie Spider-Man: Into the Spider-Verse, Kasian operates behind the scenes to smooth out the many technical elements that go into creating the movies we love. Kasian’s unusual career path demonstrates that physics is about learning skills instead of facts. She completed her bachelor’s in physics at the University of Winnipeg, then pursued a graduate degree in astronomy at the University of British Columbia. She overlapped the last year of her doctorate with her first year of law school, earning her Ph.D. in 2012 and her law degree in 2013.

Albin Gonzalez - Medical Physicist

One of the problems Albin Gonzalez solves nearly every day is how to position patients during radiation treatments for the most efficient and least painful access. He also routinely solves difficulties with the technology itself. Albin checks treatment plans and monitors the machines to make sure they’re working properly and that their output is within an acceptable range. Together with doctors, dosimetrists, radiation therapists and nurses, Albin treats around 40 patients per day with extremely high doses of radiation. Physics allows Albin to work in a fast-paced environment that’s constantly adapting to the latest technology. Right now, his department is lucky enough to use “a fantastic treatment planning system that is the latest in the market,” he says. It makes treatment plans much more efficient, which is good news for cancer patients!
Ginger Kerrick - NASA Flight Director

Ginger Kerrick uses physics every day to quickly change plans to account for weather changes and ensure that the astronauts can safely return home. Her job as a flight director can even be seen as more important than that of an astronaut because of the amount of time and skill that she has to use to think of every single scenario that could occur while the astronauts are in space. Even though Ginger could not become an astronaut, she became one of the key people who plans everything for the astronauts and gives them the instructions on how to complete their tasks. More importantly, her experience and willingness to learn new skills gave her the opportunity to work in space exploration as a NASA flight director. The setbacks that Ginger has experienced have never stopped her from pursuing a career in space exploration.

aps.org/careers/physicists/profiles/kerrick.cfm

Yung Tae Kim - Skateboarding Physicist & Educator

Yung Tae Kim grew up in Atlanta, Georgia, with an early love for skateboarding. Tae describes his dive into physics as a stroke of luck citing a high school math teacher who “even worked with me outside of class so I could study more advanced math…he was a real mentor,” Tae says. In college, Tae stumbled upon a physics class that changed the course of his academic studies, and led him to major in physics. “This [physics] class was special - it was an honors section that only 8 students bothered to sign up for,” Tae says.

After graduating and teaching as a visiting physics professor at several universities in the Chicago area, Tae took his talents and physics know-how to the video game industry, becoming a consultant and controls engineer for two games in the popular Tony Hawk skateboarding game series. Tae provided game developers with the physics behind skating tricks, allowing them to more accurately simulate them in the game. As an engineer, he revamped the game’s new interactive skateboard controller, which players stand on and move to produce on-screen tricks. In his next career move, Tae created an educational web series called “The Physics of Skateboarding with Dr. Tae” targeting skaters to get them to think scientifically about the sport. He also serves on the advisory board for the Puget Sound Community School in Seattle, Washington.

aps.org/careers/physicists/profiles/kim.cfm

Liz Kruesi - Freelance Science Writer

Liz Kruesi studied physics and astrophysics in college and graduate school, and soon found herself leaving behind mathematical equations to focus instead on the words and stories describing astronomical concepts. As a science journalist, she has been able to explore everything from dark matter and black holes to the outer planets and future telescopes. She loves diving into difficult topics — how did the universe evolve, where do the highest-energy particles come from, and what definitive proof do scientists need to declare life on another planet? She has written dozens of feature articles and hundreds of news stories covering all aspects of astronomical science. She translates complex scientific concepts, discoveries, and their stories into language that not only is understandable to anyone, but also captures the topic’s excitement and importance.

lizkruesi.com/about
Nadya Mason – Materials Physics Professor

Nadya Mason says that the best thing about having a degree in physics is that she gets to work in a fun and stimulating profession. She also gets to choose her schedule, focus on research and teaching that appeal to her, and travel and meet interesting people from around the world. Nadya’s main strategy for success is to make sure that she enjoys the work that she does. “Most physics-related jobs involve research and problem-solving, so they’re likely to be interesting and even fun,” she says.

Nadya teaches at the University of Illinois at Urbana-Champaign. Her work focuses on the way electrons behave and interact in “low dimensional” materials such as carbon nanotubes and graphene. These materials are made up of extremely thin layers of carbon, sometimes no thicker than a single carbon atom. This means that a stack of 7 million sheets would be only a millimeter thick! When dimensions are so low, electrons interact in ways that create new phenomena, which Nadya aims to explore. “The research that I do explores the fundamental science that may form the basis of the next generation of technology,” she says. For example, carbon nanotubes might play an important role in the next generation of nano-scale computers, leading to super-powerful quantum computers that could be significantly faster than the computers we use today.

Kate McAlpine - Freelance Writer

“I’m a freelance writer and sometimes rapper, specializing in physics,” says Kate McAlpine. She adds, “as a science communicator, my job is to explain research. Sometimes it’s documenting the progress of a long-term project, like my current work with the ATLAS e-News, for the ATLAS experiment on CERN’s Large Hadron Collider (LHC). Sometimes it’s reporting about a recent advance, as in the articles for New Scientist magazine.” On her work surrounding the LHC, Kate often faced challenges around defending the value of scientific research or explaining complex scientific concepts to reassure citizens about the safety of large experiments like the LHC.

Kate received her bachelor’s degree from Michigan State University, where she was studying both physics and writing. “I planned the science communicator part while still in college, but I didn’t plan rap as an aspect of my career,” says Kate. Having an exciting job is definitely one of the goals she had in mind. Kate is planning on finishing a nuclear physics rap soon, and is also working on a rap about black holes.

Amanda Joy McDonald – Actuary

Amanda Joy McDonald earned a BS in physics from Southern Nazarene University (SNU, in Bethany, OK) in 1989, where she published a paper in the Journal of Undergraduate Research in Physics. She was elected into Sigma Pi Sigma in the SNU chapter when it was chartered in 1994. Joy began her career as an actuary before graduation by taking the first actuarial exam in November 1988. Then life intervened. Needing lots of family time, she took several years off from Fellowship studies to raise children while still working as an actuary for American Fidelity. In 2006, realizing she was approaching the twentieth anniversary of starting the Fellows program, Joy set a goal to achieve the FSA before that anniversary. That goal was realized a few months early when Joy completed the final requirement in July 2008. Joy concentrated her actuarial studies in Group and Health Insurance.

Joy has remained a highly visible “hidden physicist” throughout her actuarial career. She presents talks to university math clubs and chapters of the Society of Physics Students, describing how a background in physics prepares one well for actuarial studies.
Mary Lee McJimsey - High School Physics Teacher

Mary Lee McJimsey decided to become a teacher while she was an undergraduate physics major at Cal Poly in San Luis Obispo. She was doing physics research at the time and remembers, “everyday I came in and did exactly the same thing.” Mary Lee found herself inspired to pursue a career in teaching – a goal which could provide variety and excitement in her career. This proved to be true. Responding to a question of why she loves teaching, Mary Lee says, “I understand how much this job is doing to change my community. I can help a student choose to go to college, and maybe even become one of the next engineers or physicists who’s going to change the world. Also, every single day is different…I see many teachers, every day, who come to me to have me help them solve a problem. I plan, but I never know what to expect.”

Mary Lee is now the proud mom to two boys, and recently spent a year as elementary science specialist, teaching science to students from grades K–3. She most recently worked as a physics teacher at a small school focused entirely on problem-based learning (PBL). She is temporarily out of the classroom caring for her newest family member but hopes to return to high school teaching soon.

Marta Dark McNeese - Laser Science Professor

Marta Dark McNeese teaches undergraduate students of all levels and backgrounds, from humanities students to physics majors, at Spelman College. “I enjoy interacting with my students most, but I also love having to continually learn new things,” she says. Marta gets ample opportunities to learn new things while she works on her latest research projects. The focus of her research has shifted from knee cartilage to light-emitting materials. Marta’s main project deals with synthesizing molecules that can give off light when they’re hit with light or when voltage is applied. She’s interested in these so-called “electroluminescence properties” and improving them. Marta’s lab is experimenting with adding metals to the molecule of interest, in hopes that this will improve the electroluminescence of the molecule. Her work has applications in light-emitting devices, diodes for displays, and even flexible light-emitting materials.

Deborah Moore - Environmental Consultant

Deborah Moore is an award-winning scientist, advocate, changemaker, mother, and nature lover. While she may not be a household name to you, her work has touched millions of lives and thousands of square miles of nature around the world. She has led winning campaigns across a wide range of issues, from river restoration and Indian water rights agreements in the western U.S. to fighting destructive dams around the world, and from establishing green and healthy school programs that get schools to go solar and kids out in nature to advancing the human rights of indigenous peoples. Throughout her varied career, Deborah has held roles as a research scientist, environmental advocate, non-profit director, educator, foundation consultant, and coalition builder, from small start-ups to large global initiatives. “I am an award-winning changemaker, advocate, scientist, and social entrepreneur for the environment and human rights with experience advancing sustainability, social equity, and youth engagement in the U.S. and internationally. I produce tangible results with lasting value by bringing together people with diverse perspectives to forge broadly supported solutions. My passions are climate change, water, and children - all are fundamental to a healthy future!”
**Carlane Pittman** - Director for Outreach

Carlane Pittman is responsible for student concerns and student advising at the College of William and Mary. She also coordinates and maintains the outreach efforts of the physics department to recruit and advise students. She enjoys seeing students benefit from my educational programs, and promoting science at the same time. Carlane’s main focus for the past 21 years while at College of William and Mary has been in the area of college student development including classroom and out of classroom experiences. She received her B.S. in physics from Spelman College and then her M.A. in education from Hampton University.

[spsnational.org/career-resources/physicist-profiles/carlane-pittman](spsnational.org/career-resources/physicist-profiles/carlane-pittman)

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**Allison Porter** - Biophysics Technician

Allison Porter had always been interested in the sciences, and had showed special interest in becoming a doctor, partially due to her aunt’s fight with ovarian cancer. In high school, she had a physics class that she particularly enjoyed. In the class, she was introduced to astrophysics that allowed students to create a simulated solar system by determining objects masses and velocities. When going through her undergraduate years, she wanted to choose a major that gave some breadth to her education, and her good experience in her high school physics class helped steer her towards astrophysics. "Making use of my talents, I think a lot of it is from just a philosophical standpoint, studying things that are much larger than we can really comprehend, I was very interested in big bang cosmology, the origins of the universe.” After graduating from Harvard, Porter entered the Miss America pageant, representing her state of Washington. She chose the pageant due to its goal to develop well-rounded women, and currently employs her role as Miss Washington to raise awareness of cancer prevention, treatment, and funding. She is currently in the MD Program at the University of Washington. Aside from her work, Allison Porter is helping other people by being involved in a wide range of community support activities. She has spent time in Mexico doing disease education, Calcutta working at a disabled children’s orphanage, and Ecuador as a part of a mobile surgery unit.

[physicscentral.com/explore/people/porter.cfm](physicscentral.com/explore/people/porter.cfm)

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**Sara Seager** - Astronomer and Planetary Scientist

Sara Seager is a Canadian-American astronomer and planetary scientist. She is a professor at the Massachusetts Institute of Technology and is known for her work on exoplanets and their atmospheres. She has pioneered many research areas of characterizing exoplanets with concepts and methods that now form the foundation of the field of exoplanet atmospheres. Her present research focuses on the search for life by way of exoplanet atmospheric “biosignature” gases has also led to research in the evolution of life through chemical space. Sara is the author of two textbooks on these topics. She has been recognized for this research by Popular Science, Discover Magazine, Nature, and TIME Magazine. Seager was awarded a MacArthur Fellowship in 2013 citing her theoretical work on detecting chemical signatures on exoplanet atmospheres and developing low-cost space observatories to observe planetary transits.

[en.wikipedia.org/wiki/Sara_Seager](en.wikipedia.org/wiki/Sara_Seager)
**Maggie Seeds - Associate Consultant**

Maggie Seeds was always a stargazer and wanted to pursue that passion in her undergraduate education. Maggie attended Appalachian State University where astronomy was a concentration available to physics majors. She felt that physics was a natural path of study for her, and found that she enjoyed the mathematical side of physics, working through difficult challenges and finally arriving at the answer to complicated problems. Today, Maggie is a consultant at Clarkston Consulting (N.C.), a management and technology consulting firm which focuses on consumer products and the life sciences industries. As a consultant, Maggie plays many different roles depending on a client’s needs. She says these range “from technical to strategic, across supply chain and business process areas.” The terms “supply chain” and “business process” refer to how raw materials make their way into a finished, marketable product.

Maggie says that one of the reasons she chose this career path was because she enjoyed having to be flexible and having to examine a problem from many different angles. She knew that she wanted to utilize the critical thinking skills she’d learned studying physics, but she also wanted to travel and take on a variety of complex problems. She says that consulting filled all of these needs, since every client is different and has a new, interesting problem.

[aps.org/careers/physicists/profiles/seeds.cfm](aps.org/careers/physicists/profiles/seeds.cfm)

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**Kate Shaw - Experimental Particle Physicist**

Kate Shaw is an experimental particle physicist working on the ATLAS Experiment at the Large Hadron Collider (LHC). She is a lecturer at the University of Sussex (UK) and a staff scientist at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. She has worked on the ATLAS Experiment since 2006 when she was doing her Ph.D. at the University of Sheffield. Her work includes research into the Top Quark, which is the heaviest known fundamental particle, and research on the Higgs Boson, the recently discovered particle that allows fundamental particles to acquire their different masses. Kate also worked on luminosity calibration and determination, and commissioning of the Semiconductor Tracker (SCT), part of the inner detector of ATLAS. Kate works intensively in physics outreach and public engagement. She was the ATLAS outreach coordinator for 5 years, and in 2015 won the EPS outreach prize. She is passionate to reach those who might have less access to science or are a minority in the field. In 2012, Kate founded the ICTP Physics Without Frontiers program which works to support and promote physics worldwide by empowering scientists to run educational training programs.

[kate-shaw.co.uk](kate-shaw.co.uk)

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**David Sullivan - Engineer**

David Sullivan is involved in many ways at Raytheon. First of all, he is a principal system producibility engineer within the company. He also is very involved with recruiting university students for Raytheon, as well as working with middle and high schoolers, encouraging in them an interest in math and science. In addition to his various positions within Raytheon, David is an active member of the community. He is a member of the Decision Making Committee for the Townview Science and Engineering Magnet High School. David is an active member of his church, Friendship West Baptist, where he has been involved with the men’s ministry and college groups. He has also been a coach for little league football. David’s position requires his expertise in education, research, management, and government. His job utilizes his skills in complex problem solving, synthesizing information, knowledge of physics principles, communication, and teamwork.

[careersinphysics.org/physicists/Detail.cfm?id=2332](careersinphysics.org/physicists/Detail.cfm?id=2332)
Urszula Tajchman - Pediatric Cardiologist

In her job, Urszula Tajchman treats children with heart disease, as well as conducts research in molecular biology. Urszula received her medical training at the Johns Hopkins University. She then did her residency in pediatrics at the University of Colorado, and a fellowship in pediatric cardiology at the University of Iowa. She worked as a pediatric cardiologist at the University of South Dakota before becoming the first pediatric cardiologist in Central Oregon in 2002. Urszula is board certified in pediatrics and pediatric cardiology. She says that the best things about her job are caring for patients, teaching children and parents about their health, and studying therapies for disease.

[a link to Urszula Tajchman's profile]

Aaron Weiss - Prototype Engineer

Studying physics fueled Aaron Weiss’ curiosity. “When I started to grasp how complex and diverse our world can be, things started clicking, and my curiosity shot through the roof,” he says. Aaron was always interested in nearly every scientific field, so he kept his options open after graduation. He soon found his way to a small hardware company and describes the experience thus: “It was a scrappy group of engineers cooking circuit boards on hot plates in a tiny room with no ventilation. Bingo… [they were] pioneering open source hardware and I fell in love with building electronics and haven’t stopped since.”

Now, Aaron works at a research and development facility founded by Google and contributes to many exciting new technologies including space-based projects and self-driving cars. Aaron is part of the machine learning team in the robotics division. Aaron has also founded his own company, a design outfit called Bitsmashed. With Bitsmashed, Aaron has created a variety of power sensing and GPS tracking systems such as Hawkpack—a solar powered cellular enabled backpack worn by large birds of prey that can track their motion. Aaron is constantly applying his physics knowledge to work on exciting projects.

[a link to Aaron Weiss's profile]

Alice White - Materials Scientist

Alice first got into science in high school and went on to study chemistry at Middlebury College, a small liberal arts school in Vermont. Alice loved Middlebury’s close-knit and supportive science department and one semester took an organic chemistry and physics course at the same time. She found she didn’t like the messiness of her chemistry lab, but loved all the math used in physics. The experience led her to change her major and complete her degree in physics.

Alice is now a research scientist and works at the Boston University Department of Mechanical Engineering as Chair. Her technical background focuses on experimental solid-state physics and fabrication of optical components. She’s received many awards and fellowships for her work, which has led to over 125 publications and 7 patents. She has a lot of support from her family and has had good mentors in her career. She strives to give back through mentorship, and outreach such as talks and physics demonstrations at local elementary schools. She says, “I really benefited…and it’s something that I’m happy to give back.”

[a link to Alice White's profile]
PART 1: Use this sheet to plan your career profile.

I want to pursue a career in ____________________________

In this career I will focus on:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

What do you hope to contribute or accomplish through your career choice? (How will you help the world or contribute to society?)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

I need the following skills (What skills or traits do you need to pursue this career?)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Based on what you learned from the physicist profiles, what are the ways you could achieve this career with a degree in physics? (How can a degree in physics lead you into this career or support your growth in this career?)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
PART 2: Using the information you documented in Part 1, create a profile of your future self that achieves your career goals with a degree in physics. Imagine that this profile will be read by students like you to illustrate that physics can help them achieve their goals. Use the template below (2 page maximum).

**WHO I AM**
[Describe who you are and aspects of your background that are important to you].

**WHY PHYSICS**
[Give a brief personal background including how you became interested in physics, the degree(s) you earned, and the steps you took to reach your career through physics.]

**USING PHYSICS**
[Describe the skills and traits from your physics degree that you use in your career. Describe ways that you have contributed to your field, or ways your work benefits others, or interesting projects/accomplishments that have occurred in your career.]

**ADVICE FOR STUDENTS**
[Suggest ways for students to pursue their career goals using a physics degree, what they may not know about physics, etc.]
### RUBRIC FOR GRADING PERSONAL CAREER PROFILES

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TARGET (1 POINT)</th>
<th>UNACCEPTABLE (0 POINTS)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture</td>
<td>Student includes a picture of themselves, preferably illustrating their career.</td>
<td>Student picture is not included.</td>
<td></td>
</tr>
<tr>
<td>Who I Am</td>
<td>Describes: (i) meaningful aspects of their background, (ii) what is important to them.</td>
<td>Missing one or both of the following: (i) aspects of their background, (ii) what is important to them.</td>
<td></td>
</tr>
<tr>
<td>Why Physics</td>
<td>Incorporates: (i) how they became interested in physics, (ii) the degree(s) they earned, (iii) steps they took to reach their career using physics.</td>
<td>Missing multiple parts of the following: (i) how they became interested in physics, (ii) the degree(s) they earned, and (iii) steps they took to reach their career using physics.</td>
<td></td>
</tr>
<tr>
<td>Using Physics</td>
<td>Includes: (i) skills and traits from a physics degree that they use in their career, (ii) ways that they have contributed (e.g. to their field, to benefit others, interesting projects/accomplishments).</td>
<td>Missing one or both of the following: (i) skills and traits from a physics degree that they use in their career, (ii) ways that they have contributed.</td>
<td></td>
</tr>
<tr>
<td>Advice for Students</td>
<td>Describes: (i) ways for students to pursue their career goals using a physics degree, (ii) what they may not know about physics.</td>
<td>Missing one or both of the following: (i) ways for students to pursue their career goals using a physics degree, (ii) what they may not know about physics.</td>
<td></td>
</tr>
<tr>
<td>Overall (Bonus)</td>
<td>Excellent descriptions and visual presentation of their profile. This is definitely one to post in class!</td>
<td>Descriptions or visual presentation need work.</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL (OUT OF 5)**
SAMPLE CAREER PROFILE #1

Cami Monsalve
Sustainable Energy Innovator

WHO I AM
I am a Colombian woman, who moved to the United States when I was 8 years old. It is important for me to be passionate and motivated in my career.

WHY PHYSICS
I got inspired by my high school teacher, he helped me see my potential and strengths. At first, I completed a degree in biology because I wanted to be a medical doctor. All I wanted to do was help people and challenge myself while I was at it. Therefore, I went to complete my second bachelor's in physics, which taught me tenacity. I also participated in my university's StartUp Hub, which taught me how to be an entrepreneur.

USING PHYSICS
In my career I have focused on designing simple artifacts for sustainable power. For example, creating a water filter that uses solar energy. Designing this project took a team of scientists and engineers, who all collaborated. Simultaneously, I worked with environmentalist and social workers to determine exterior design that would be functional for the water filter. Programming helped in this project especially when designing the proper solar panel to harvest enough energy for the filter, which I thankfully learned in my physics degree.

ADVICE FOR STUDENTS
My advice for any student who is pursuing a physics degree is to become an active agent of your education and be comfortable with your own limits. Many times, the explanation of a professor is not enough for you, ask fearlessly until the concept makes sense to you. Also, there are times where you must review basic math concepts and skills to understand better either the concept or the math for physics.
SAMPLE CAREER PROFILE #2

Pseudonym Smith
Petroleum Engineer

WHO I AM
Hi, I’m a petroleum engineer. I grew up in a household that values education and financial success and stability, which in turn influenced how I think of the world and what job I want in the future. I decided that I wanted a high paying job at a very young age, I just didn’t know what I wanted to do until I was introduced to this field of engineering of course.

WHY PHYSICS
Before I determined that this is what I wanted to do, my parents were pushing me to be a doctor or a lawyer or a surgeon due to the financial success and stability that come with those jobs, but quite frankly I was never really interested in those jobs, I found them rather dull and I like to have fun every now and then but those jobs require constant hard work, which my family also values a lot, and I wasn’t really about that life. I was very confused about what I wanted to do later in life until I came across physics in high school. My teacher back then, had assigned us to do this project about a career that we can get into with a physics degree, and that’s essentially when I fell in love with this career. The first step that I took to have a shot at a future in this career was to graduate high school with good grades, then the next step was to go to college and get a degree in both physics, and petroleum engineering. After doing all that, I went and looked for an internship at an oil company, which I did end up finding, and after the internship they ended up offering me a job there and ever since then my life has been great as petroleum engineering is a high paying and stable career to have.

USING PHYSICS
I have learned many skills while getting my physics degree that have helped me greatly in my career, such as critical thinking and problem-solving skills, which I use everyday when I’m at
home. In fact, I even use these skills when I’m not home as well, I use those skills everywhere, they are very essential and wonderful skills to have. My career provides new opportunities to make everyday oil prices cheaper and cheaper as my job is to come up with new, cheaper, and more effective ways to extract oil. I am very proud to be a part of this career, and very happy of all the different ways in which I help make people’s lives better, whether it be helping the company that I’m working for make more profit, which would make me more money as well, or help people save on gas prices.

ADVICE FOR STUDENTS
There are many different career paths that you can go for with a physics degree. The first thing that I would suggest that you do is to first research all of those careers, see which one of them interest you the most, then look up what degrees and qualifications that you need to be able to achieve those careers, then just go for it, and if you ever get scared of failure then just think of the following quote: “You miss 100% of the shots that you don’t take.” -Wayne Gretzky
Lesson Plan: Careers in Physics

APPENDIX 5

Physics Careers and Salaries Presentation

Job Stability & Satisfaction
Based on national surveys of students with bachelor’s degrees in physics
- High employment rates (95%)
- High job satisfaction in terms of
  - Feelings of job security
    - 75% to 93% (depending on sector) felt secure
  - Overall satisfaction
    - 71% to 90% (depending on sector) felt a sense of satisfaction

Job Opportunities
- Flexible options and sectors including:
  - National Labs
  - Professional Schools (e.g. Medicine, Health)
  - Environmental/Climate Science, Energy
  - Space Science
  - Government/Policy
  - Public Administration, Business
  - Communication (e.g. Science Writing, Media)
  - Education (e.g. High School, College/University)
  - Engineering, Computing
  - Arts (e.g. Music, Television)
  - Not-for-Profit Organizations
  - Graduate Studies (e.g. multiple STEM disciplines)

Surprising Facts: Medicine
- Physics Majors and Medical School
  - Physics majors get very high scores on the MCATs

<table>
<thead>
<tr>
<th>Subject</th>
<th>Physical Science</th>
<th>Biological Science</th>
<th>Verbal Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics</td>
<td>10.8</td>
<td>10.5</td>
<td>9.9</td>
</tr>
<tr>
<td>Physics</td>
<td>11.1</td>
<td>10.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Biomedical Engng</td>
<td>11.1</td>
<td>10.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Mathematics</td>
<td>10.8</td>
<td>10.4</td>
<td>9.3</td>
</tr>
<tr>
<td>Electrical Engng</td>
<td>10.9</td>
<td>10.1</td>
<td>9.4</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>10.1</td>
<td>10.5</td>
<td>9.5</td>
</tr>
<tr>
<td>English</td>
<td>9.6</td>
<td>10.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>10.1</td>
<td>10.4</td>
<td>9.0</td>
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<tr>
<td>Chemistry</td>
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<td>10.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Microbiology</td>
<td>9.2</td>
<td>10.1</td>
<td>8.8</td>
</tr>
<tr>
<td>Psychology</td>
<td>9.1</td>
<td>9.5</td>
<td>9.1</td>
</tr>
<tr>
<td>Biology</td>
<td>9.0</td>
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<td>8.7</td>
</tr>
<tr>
<td>Premedical</td>
<td>8.3</td>
<td>8.9</td>
<td>8.1</td>
</tr>
<tr>
<td>All Majors</td>
<td>9.5</td>
<td>9.9</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Surprising Facts: Law
- Physics Majors and Law School
  - Physics majors get very high scores on the LSATs

<table>
<thead>
<tr>
<th>Subject</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>162.2</td>
</tr>
<tr>
<td>Physics</td>
<td>162.1</td>
</tr>
<tr>
<td>Economics</td>
<td>159.1</td>
</tr>
<tr>
<td>Engineering</td>
<td>157.3</td>
</tr>
<tr>
<td>Chemistry</td>
<td>156.7</td>
</tr>
<tr>
<td>History</td>
<td>156.7</td>
</tr>
<tr>
<td>English</td>
<td>155.8</td>
</tr>
<tr>
<td>Biology</td>
<td>155.2</td>
</tr>
<tr>
<td>Political Science</td>
<td>154.3</td>
</tr>
<tr>
<td>Psychology</td>
<td>153.3</td>
</tr>
<tr>
<td>Computer Science</td>
<td>152.3</td>
</tr>
<tr>
<td>Pre-Law</td>
<td>149.0</td>
</tr>
<tr>
<td>Criminal Justice</td>
<td>145.3</td>
</tr>
<tr>
<td>All Majors</td>
<td>153.6</td>
</tr>
</tbody>
</table>
Lesson Plan: Careers in Physics

Surprising Facts: Salaries

- Physics Majors and Earnings
  - Physics bachelors earn comparatively more

Surprising Facts: Helping Society

- Physics Majors Help Others
  - Improving people's health
    - Diagnosis and treatment of illness, for example:
      - Cancer treatment using radiation, new nanobot technology to target individual cancer cells
      - Body imaging using X-rays, ultrasound, NMR and PET scans
      - New methods using infrared light to monitor our blood
  - Addressing environmental issues
    - Energy needs and climate change effects, for example:
      - New renewable energy technology
      - Climate change effects on humans, animals (e.g. penguin populations), and land (size of the Sahara Desert)
      - Environmentally friendly transportation methods
  - And many more...

Summary

Students who earn a degree in physics:
- Have high employment and job satisfaction
- Work in many different sectors (STEM/non-STEM)
- Gain skills that give them a competitive edge for Medical and Law School
- Earn comparatively higher salaries than most other bachelor's degrees
- Have the opportunity to help society in substantial ways

Exit Slip

What surprised you about the:
- areas in which physicists work?
- skills physicists apply working in such diverse areas?
- benefit physicists can have on the lives of others?

References


Women in Physics

LESSON PLAN
This material is based upon work supported by the National Science Foundation under Grant Nos. 1720810, 1720869, 1720917, and 1721021. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
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 perform an Internet search for physicists to identify trends in stereotypes about those who work in physics.

2. Students read biographies of historical physicists as well as one modern physicist and complete a reflection worksheet.

3. 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.

4. Students discuss the outcomes of their Internet search and biographical analyses, and synthesize conclusions from the whole class discussion.

5. Students voluntarily contribute their own experiences with gender bias to a class discussion, and consider how this might influence their own views about gendered careers and a future in physics.

6. Students respond to a prompt about their own experience with gender bias.

Learn more at [STEPUPphysics.org](https://www.STEPUPphysics.org) and register to access instructional support & FAQs
Lesson Plan: Women in Physics

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.]

Future Gains – Women in Physics

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 suggested the optimal timing for implementation is (i) after a classroom community is established and (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.

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

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.
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)

<table>
<thead>
<tr>
<th>What the Teacher Does</th>
<th>Anticipated Behaviors/Responses from Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-lesson:</strong> Assign students to complete the pre-class assignment prior to class (Appendix 1). The assignment requires them to:</td>
<td>Pre-lesson: Students will complete the Women in Physics Pre-Assignment.</td>
</tr>
<tr>
<td>• 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)</td>
<td></td>
</tr>
<tr>
<td>• 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)</td>
<td></td>
</tr>
<tr>
<td>• Respond to related questions</td>
<td></td>
</tr>
</tbody>
</table>

1. **In class (Appendix 2, Slide 2; 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?
   - When did the women on the list live?
   
   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).

   • 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)

<table>
<thead>
<tr>
<th>What the Teacher Does</th>
<th>Anticipated Behaviors/Responses from Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interactive presentation (est. time = 65 minutes)</strong></td>
<td>1. Students will read the guidelines and ask questions to ensure they understand.</td>
</tr>
<tr>
<td>Lead a whole class discussion organized around the slides (Appendix 2). Think/Pair/Share technique (see here or other online resources) can be used throughout this discussion to stimulate conversation</td>
<td></td>
</tr>
<tr>
<td>1. <strong>Introduce guidelines (Critical lesson component)</strong>: Slide 3; est. time = 5 minutes. At the beginning of the presentation/discussion (after the Google search discussion), introduce these guidelines to students (or refer to your class conduct rules if you have already established them):</td>
<td></td>
</tr>
<tr>
<td>• Share air time equitably. Know yourself, balance your listening and talking.</td>
<td></td>
</tr>
<tr>
<td>• Value differences. Remember that your perspective is not the only one.</td>
<td></td>
</tr>
<tr>
<td>• Argue using evidence. Back what you have to say with data.</td>
<td></td>
</tr>
<tr>
<td>• Make sure everyone feels safe. Safe is not the same as comfortable.</td>
<td></td>
</tr>
<tr>
<td>• Discomfort is OK. Identify your learning edge and push it.</td>
<td></td>
</tr>
<tr>
<td>• Own your impact. Your intentions may not be the same as your impact.</td>
<td></td>
</tr>
<tr>
<td>2. <strong>Opening Slides</strong>: slides 4–18; est. time = 20 minutes.</td>
<td>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 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.</td>
</tr>
<tr>
<td>• 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).</td>
<td></td>
</tr>
<tr>
<td>• In Slide 6, 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).</td>
<td></td>
</tr>
<tr>
<td>3. <strong>Gendered professions</strong>: slides 19–20; est. time = 10 minutes. Prompts:</td>
<td>3. Possible responses to gendered professions:</td>
</tr>
<tr>
<td>A. Why do you think women appear in particular science fields more than others?</td>
<td>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).</td>
</tr>
<tr>
<td>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?</td>
<td>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.</td>
</tr>
<tr>
<td>C. What patterns have you noticed in who pursues different careers? Why do you think we see these differences?</td>
<td>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.</td>
</tr>
<tr>
<td>• Encourage students to notice gender disparities in any particular field and to consider why these disparities exist.</td>
<td></td>
</tr>
</tbody>
</table>
**4. Personal experiences (Critical lesson component):** slide 21; 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. 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.
- **Prompt:** Describe experiences you or a friend has had related to science and gender issues. Detailed questions: who do you feel comfortable working with in class? Do you feel more comfortable in any particular class? Have you felt your abilities being questioned? Have you seen or experienced gender biases in your own life, either purposeful or unintentional?
- **As students share anonymous experiences, 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.

**4. Students will write a response to the prompt on a piece of paper and then share with a partner. They will then write 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

**5. Career Influences:** slide 22; 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.

**5. Students will voluntarily share viewpoints and experiences and be responded to by other students.**

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**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)**

<table>
<thead>
<tr>
<th>What the Teacher Does</th>
<th>Anticipated Behaviors/Responses from Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Proposing strategies:</strong> slide 23; est. time = 5 minutes.</td>
<td><strong>1. Students will write their ideas about how to support diversity in physics.</strong></td>
</tr>
<tr>
<td>- Ask students to write a response to the prompt on a piece of paper to be shared anonymously. Collect the papers, mix them up, and pass them out.</td>
<td></td>
</tr>
<tr>
<td>- Prompt: What can be done to support diversity in physics? What could you do?</td>
<td></td>
</tr>
</tbody>
</table>
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.

- 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.

Post-Lesson: Assign students to complete the **Women in Physics Post-Assignment** (Appendix 3). The assignment has them write about their views after the class discussion.

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### EXTENSIONS

#### Potential tech enhancements for live visualization of student responses

- spsedtech.wordpress.com/2013/08/24/socratic-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.

- mentimeter.com - Mentimeter can also be used to create visualizations of students’ responses

#### 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)

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### BIBLIOGRAPHY


### PHYSICIST INFORMATION WEBSITES:

- Lise Meitner: 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:

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

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 (www.sdsc.edu/ScienceWomen/meitner.html) or Jocelyn Bell Burnell (biography.com/people/jocelyn-bell-burnell-9206018)
- 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.
Lesson Plan: Women in Physics

Women in Physics Slides

APPENDIX 2

Learn more at STEPUPphysics.org

What trends do you notice about the physicists you found in your google search?

Guidelines for Conduct During Discussion

- Share air time equitably
- Value differences
- Own your impact
- Make sure everyone feels safe
- Discomfort is okay
- Argue using evidence

Percentage of Women in Science

- Which science field do you think has the highest percentage of women in it?
  - A. Math the same
  - B. Biology
  - C. Chemistry
  - D. Physics
  - E. All about

- Which field do you think has the lowest percentage of women?
  - A. Math the same
  - B. Biology
  - C. Chemistry
  - D. Physics
  - E. All about

Percentage of Bachelor’s Degrees Earned by Women, by Major

Source: APS and IPEDS Completion Survey

Why are women better represented in some fields over others?

- For example, in the US, why does physics/engineering have a lower proportion of bachelors degrees awarded to women than biology/chemistry?
- Which of the following countries has the highest percentage of women in physics? The lowest?
  - A. Germany
  - B. Argentina
  - C. Iran
  - D. USA
  - E. All about the same
  - F. All

---

Lesson Plan: Women in Physics 11
Lesson Plan: Women in Physics

**Women in Physics Slides**

**APPENDIX 2**

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### Percentage of Undergraduate Physics Degrees Awarded to Women

```
<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>30</td>
</tr>
<tr>
<td>USA</td>
<td>35</td>
</tr>
<tr>
<td>Canada</td>
<td>40</td>
</tr>
<tr>
<td>Australia</td>
<td>45</td>
</tr>
<tr>
<td>Italy</td>
<td>50</td>
</tr>
<tr>
<td>Argentina</td>
<td>55</td>
</tr>
<tr>
<td>Albania</td>
<td>60</td>
</tr>
<tr>
<td>Iran</td>
<td>65</td>
</tr>
</tbody>
</table>
```


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### What is happening in Iran?

- Families invest in the education of girls
- National policies support girls in physics
- Boys losing interest in physics


---

### What is happening in Germany?

- Women take the primary role in parenthood
- Women’s accomplishments are underappreciated
- Women underpaid
- Only now considering recruiting women into physics at the secondary level


---

### Women in Physics Internationally

What does the information about women in physics internationally suggest about the causes of women’s underrepresentation in physics in the US?

---

### Academic Achievement

- Do you think there are gender differences in physics grades in high school or college?
- If you think there are differences, what are the causes? Exam bias, ability differences, or something else? Why?

---

### Academic Achievement

- Men and women achieve similar grades in high school and university physics
- The difference in science and math achievement between boys and girls is very small and varies more with country than between genders

Hazari et al., 2007; Hazari et al., 2018; Hyde and Linn, 2006
Lesson Plan: Women in Physics

Unconscious Bias

- Even small grade differences that do exist may be due to bias. How does this happen?

What is unconscious bias?

- Unconscious bias refers to the unconscious sorting of people, often based on stereotypes and beliefs, bypassing rational and logical thinking
- Sexist behavior can arise even when people are not consciously sexist.
- All people have some degree of unconscious bias and many people even hold unconscious bias towards the groups that they belong
- Becoming aware of your own unconscious biases is the first step to overcoming them

How early can unconscious bias emerge?

In the US, girls age 6 are less likely than boys to believe that members of their gender are ‘really, really smart’, and avoid activities associated with being “really, really smart”. Why?

Another example of unconscious bias

Even after accounting for actual class performance and outspokenness, men assumed other men knew the content better than women. Does this happen here?

Women in Physics Today

- The challenges faced by women today are often not as obvious as the challenges faced by women in the past, but they are still very real.
- Sociocultural issues influence women’s career decisions.
- Sexism today often occurs in the form of unconscious biases. Having these biases does not make anyone a bad person. Becoming aware of our own unconscious biases is necessary in order to overcome them.

Have you considered physics?

- In the US, UK, and Canada, thousands of women physics majors and their allies gather each year in support
- Don’t let unconscious bias keep you from considering a physics career!

Source: Conferences for Undergraduate Women in Physics (CUWiP)
Gendered Professions

Why do you think women appear in particular science fields more than others?
What gender are your doctors and nurses?
What about people you know in other technical professions (e.g. engineering)?

Stop and Reflect – write your answers

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 being questioned?

What can we do?

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

References

APPENDIX 2
Lesson Plan: Women in Physics

Supplemental Slides

An effect of unconscious bias

The proportion of Physics Bachelor's Degrees Awarded to African-Americans and Hispanics-Americans.

- The more a field is associated with intellectual ability, the lower the percentage of PhDs in that field who are women.

An effect of unconscious bias

In identical online classes, instructors received better evaluations using a man’s name than a woman’s name. Gender bias in evaluations also occurs for physics teachers.

An effect of unconscious bias

- Women are treated unfairly in science even today though scientists may not be consciously aware of this.
- How can we counteract these effects?
POST-ASSIGNMENT

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?
Women in Physics Internationally

Summary

The representation of women in physics at the undergraduate level varies widely between countries, with Iran having the highest percentage of women in physics and western cultures such as the US and Germany having the lowest. Even in countries with relatively high percentages of female undergraduates, women are underrepresented at the faculty level.

The reasons for these disparities are not well known, but representatives from different countries do posit some ideas. Albania has the clearest reason for its lack of a gender gap: students are assigned their majors based on their grades and are not free to choose. This shows that women have equal abilities in physics, a fact also reported by Italy and Iran. Iranian sources cite families’ investments in educating girls, national policies, and boys’ decreasing interest in physics as reasons for the high representation of women in undergraduate physics.

The state of physics is in flux in Argentina, where widespread government funding for science has been implemented only recently and where a positive perception of scientists is generally on the rise. In Italy, female physicists are disproportionately represented in the subfields of applied physics, history of physics, and didactics of physics, while in Albania, women in graduate level physics gravitate towards environmental physics, physics education, and biophysics. Countries such as Canada, Germany, and Australia invest in initiatives to attract women into physics but have seen relatively little success. Included below is a summary of multiple papers from the IUPAP International Conference on Women in Physics, with information from each country & a relative reference.

Germany


In 2012, the percentage of university degrees in physics awarded to women in Germany was slightly less than 20%. The percentage of physics Ph.D.’s awarded to women was similar, but the percentage of women in the German Physical Society (Deutsche Physikalische Gesellschaft, DPG) was lower (14%). The participation of women in undergraduate physics remained relatively constant from 2005-2015, but the percentage of women at the faculty level increased. The report cites that parenthood affects female physicists’ careers “distinctly more strongly than it does for men” and found that female physicists’ professional competence and accomplishments are less appreciated. Furthermore, women in physics careers make less money than men with the same duties, responsibilities, and educational level. The efforts of the DPG Working Group on Gender Equality, founded in 1998, are credited with increasing the number of women in leadership positions in their organization and the number of women giving DPG plenary talks. Further efforts of that group include organizing the German Conference of Women in Physics and the DPG Mentoring program. They were also considering a program to encourage girls at the high school level to enter physics.

Canada pt. 1


(The 2015 paper does not have the statistics for physics, specifically, but the 2005 paper does. See below.) In 2015, 24% of all undergraduates in the physical sciences, computer science, engineering, and mathematics were women. Additionally, at the full professor level, only 9% of physicists were women. There are many efforts to increase the representation of women in physics in Canada. The Natural Sciences and Engineering Research Council (NSERC) supports parental leave for trainees and grant deferral during times of leave. The Canadian Conference for Undergraduate Women in Physics aims to support women at the undergraduate level. Additionally, many outreach programs aim to recruit middle school and high school girls into physics. Despite these efforts, women remain underrepresented in physics.

Canada pt. 2


In 2005, 22% of undergraduate physics students were women. Compared with the percentage for the physical sciences, computer science, engineering, and mathematics in 2015, this suggests that there has not been a significant change over the past decade.

Australia


The percentage of women in physics undergraduate majors in Australia decreased seven points from 2002 to 2013 (28% to 21%). The report cited that 21% of physics staff at universities were women. On average, women were paid less and held less senior positions than men. Women’s careers were also seen to be more disrupted by private life concerns than men’s, causing women to take more breaks from their careers, spend more time on teaching, and complete less postdoctoral/research fellowships than men. Pointing to the fact that the Australian Institute of Physics women’s group has not been active since 2010, the report says perhaps “the physics community has taken their ‘eye off the ball.’” Thus, despite a perceived “high level of goodwill” towards women in physics, the research suggests that this is not enough.
Italy

The report from Italy found that though women constituted the majority of graduate students (58%) across all fields, women were a minority in physics graduate degrees and reported no significant changes since 2003. Women represented ~40% of the undergraduate and graduate “physics science” degrees and only ~32% of “pure physics” degrees at these levels. Note that “physics science” includes pure and applied physics, history of physics, and didactics of physics. The percentage of women steadily drops at the researcher, assistant professor, and full professor levels, and the report notes that these drops are not due to performance since women and men perform at equal levels in their studies. In 1997, the European Union adopted an Equal Opportunity policy to achieve gender equity. Subsequent affirmative action plans that were required included such practices as balancing work and personal life and being culturally aware. However, the widespread implementation of these policies does not appear to have resulted in appreciable changes in women’s representation in physics careers over the intervening years.

Argentina

Though the total female enrollment in undergraduate physics in Argentina dropped from 31% in the 1990's to 27% in the 2000's, the percentage of graduating students was 34% women for the latter decade. Government support for scientific research increased significantly from 2003 to 2013 thus attracting more people to scientific careers. The percentage of graduate scholarships and research grants awarded to women has increased, and several women hold leadership positions in scientific agencies. However, the percentage of women that are employed in research positions decreased. Hence, the trends for women’s representation in physics in Argentina are mixed.

Albania

Only one university in Albania supports physics doctoral students, the University of Tirana. At the graduate level, the percentage of women was 70% in 2012, up nearly 30% from the prior year. However, women are concentrated in specific fields. The majority of doctoral students in the areas of physics education, environmental physics, and biophysics are women. At the undergraduate level, 50% of the physics majors were women in 2014. This is due in part to the fact that students are assigned their majors based on their grades rather than their preferences. Challenges facing physics students of all genders after graduate school include a paucity of government funding and lack of affordable child care. Despite these problems, large percentages of women physicists are being promoted in academia and have begun taking on upper-level administration positions. The Ministry of Education and Science is funding gender equality initiatives primarily to connect Albanian women physicists with women physicists in other countries, and both this ministry and the Institute of Applied Nuclear Physics are directed by women.

Iran

Overall, representation of women in physics in Iran has increased dramatically. For example, from 2012-2015 the representation of women at the Ph.D. level rose from 39% to 47%. Additionally, 60% of undergraduate and master's students in physics were women in 2015. This increase of women in physics is attributed to families investing in the education of girls, supportive national policies, and boys’ decreasing interest in physics. Interestingly, both genders perform similarly on physics assessments. Since there is some lag in women matriculating into higher degrees and careers in physics, women still make up a very small fraction of physics faculty members and instructors. Women are very active in the Physical Society of Iran (PSI), with 39% of associate members and 28% of permanent members being women in 2013. A Women in Physics branch of PSI was established in 2012 and has established plans to further increase the representation of women in physics.
Everyday Actions
PUBLICATION DATE: JUNE 2019

STEP UP

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This material is based upon the work supported by the National Science Foundation under Grant Nos. 1720810, 1720869, 1720917, and 1721021. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Use the self-reflection below to think about how well your everyday actions support an inclusive physics classroom community. Then, use the Everyday Actions guidelines on the following pages to work to improve your practice as you support young women in physics. Try choosing one area to focus on each week.

### EVERYDAY ACTIONS SELF-REFLECTION

*On a scale of 1-5, how would you rate your use of the everyday actions?*

<table>
<thead>
<tr>
<th>When you talk to students individually, do you:</th>
<th>NOT AT ALL</th>
<th>VERY MUCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss with students why they would be a good fit for physics</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Direct other students to female students for help</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Direct students toward clubs, camps, internships, or other programs</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Encourage students to take advantage of academic opportunities in physics</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Connect with students about what they value and are interested in</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Provide students with feedback, reassurance, and personal stories of struggle</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When you facilitate group work/labs, do you:</th>
<th>NOT AT ALL</th>
<th>VERY MUCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid isolating women in a group of mostly men</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Ensure women are taking active roles</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Bolster confidence around lab equipment</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Teach collaboration skills during or before initial group activities</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When you address the whole class, do you:</th>
<th>NOT AT ALL</th>
<th>VERY MUCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set expectations for success</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Promote a sense of community</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Promote a growth mindset</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Value many different types of skills, such as communication and teamwork</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Distribute attention during class discussions</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>When you plan and assess, do you:</th>
<th>NOT AT ALL</th>
<th>VERY MUCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate real world physics examples</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Connect physics to other disciplines</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Establish clear grading rules</td>
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<tr>
<td>Allow second chances for high stakes assessments</td>
<td>0 1 2 3 4 5</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>When you are outside the classroom, do you:</th>
<th>NOT AT ALL</th>
<th>VERY MUCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage other teachers to recommend physics to their female students</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Talk to school counselors to ensure they encourage female students to take physics and consider physics careers</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Provide school counselors with information about the breadth of jobs in physics</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Share female students’ successes and capabilities with their families</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Provide parents with information about job opportunities in physics</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Support students who want to start a physics club or take part in physics activities and events</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Find out about outreach and community activities for student engagement and encourage students to participate</td>
<td>0 1 2 3 4 5</td>
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</table>
Encourage students individually, especially young women. Promote self-confidence through explicit reinforcement of their abilities – female students tend to have less self-confidence in physics [1-4].

**Recognize students**

- Discuss with students why they would be a good fit for physics. Remind students of these messages regularly – students might not internalize the message the first time.
- Direct students to female students for help. Position them as local experts.

**Support new opportunities**

- Direct them towards clubs, camps, internships, or other programs, or even start a STEP UP Club.
- Encourage students to take advantage of academic opportunities in physics they may not have considered.

**Learn what students value**

- Connect with students about what they value and are interested in.
- Provide students with feedback, reassurance, and personal stories of struggle.
Recognize students

YOU MIGHT SAY:

• “You did a great job leading your lab group this week. This is such an important skill for a physicist. Have you considered majoring in physics?”
• “You’re a good communicator, and that would be helpful in a physics career.”
• “You have great creative ideas. Physicists need to be creative.”
• “You can explain physics very well – the fact that you can relate these concepts to everyday terms is very important.”
• “Emily did a great job with that; ask her how she approached the problem.”

Student Story

Other students asked me questions like how did you understand it this way, can you explain it to me in a simpler form? Exchanging ideas helped me realize how much I knew.”

Support new opportunities

Student Story

One year my teacher recommended that I apply for a summer internship at Yale. I didn’t get the internship, but it was encouraging to me that he thought I was good enough to be competitive.”
When You... Talk to Students Individually

Teacher Story

I was a science fair coordinator, and kids will get selected [from the district fair], so they can go to regionals. They might be on the fence about it. You can encourage them to go. Like, ‘Yeah, you should do it! You have a great project!’"

YOU MIGHT SAY:

• “I’d love to write a letter of recommendation for you; I think you’re a strong student and would support you going forward.”

• “I hope you might consider taking physics next year.” or “Tell me your thoughts about taking physics next year. I really hope you will go on in physics.”

Learn what students value

Student Story

I could see doing nuclear physics because I thought that was really interesting, like alternate energy. It’s pretty interesting.”

Student Story

One of the hardest classes that I’ve ever taken was physics. I was struggling and sought out my teacher for help. The teacher shared with me that he didn’t truly master the subject until he started teaching. This was encouraging for me to hear and affirmed that I was capable despite my self-doubt.”

NOTE: The STEP UP Careers in Physics lesson allows students to explore potential physics careers based on their interests.
Facilitate Group Work/Labs

In group activities, all students should have equal opportunity to assume active roles and contribute to group discussions. Female students are often marginalized in group work due to unsupportive group dynamics and having less prior experience with physics experimentation [5-9].

Choose group members

- Ensure women are taking active roles.
- Avoid isolating women in a group of mostly men.

Scaffold group collaboration

- Bolster confidence around lab equipment and trying things out.
- Teach collaboration skills during or before initial group activities.
Choose group members

Researcher Story

Creating small groups with high proportions of women in otherwise male-dominated fields is one way to keep women engaged and aspiring toward related careers.” [5]

Researcher Story

Groups comprised of two males and one female tended to be dominated by the male students... even when the female member was articulate and the highest ability student in the group.” [8]

Researcher Story

[Women in the physics laboratory] complained of domineering partners, clashes in temperament, being subjected to ridicule, fears that their partners didn’t respect them, and feelings that their partners understood far more than they.” [9]

Teacher Story

I hand out ‘what’s your favorite color?’ cards; then noting that many of the girls have green, I say “Okay, green is going to operate the equipment” rather than letting them choose, for example, note taker.”

YOU MIGHT SAY:

- “Make sure that no one is dominating the activity in your group and that everyone in the group is getting a chance to use the equipment, conduct the analysis, and contribute to the group discussions.”
Scaffold group collaboration

Teacher Story

“I remind students that girls are often socialized to take fewer risks and try things out. I encourage them to not be afraid to experiment since that is how we all learn and grow.”

YOU MIGHT SAY:

• “This is challenging – I had a hard time learning to use lab equipment myself, but you will know this by the end, I promise.”
• “I expect there to be mistakes, since we are learning new things. As we examine what led to our mistakes, we can improve.”

Teacher Story

“I assess students on collaboration because it shows that it matters.”

Student Story

“Our team was recognized as team of the month on the board because we all worked together effectively to create and present a collaborative project.”

NOTE: The example rubric (available in reference [10]) can be used to provide students with an outline of the behaviors needed for productive collaboration.
Address the Whole Class

In classrooms that are effective in promoting positive attitudes towards physics, teachers do the following:

Set the tone

- Set expectations for success. Provide challenging tasks and problems and make it clear that you believe students are capable of meeting these challenges.
- Promote a sense of community – students are in it together (with each other and the teacher).
- Make the students aware of what resources are available in the classroom and repeat this clear message often.
- Promote a growth mindset [11-13]. Students can have a fixed mindset about their abilities in physics (i.e., you are good at physics or you are not). Provide encouragement and support so they learn that they can improve with effort and persistence.
- Value many different types of skills including communication, teamwork, and creativity. Talk about why these skills are essential to science.
- Emphasize that science is not done in isolation. Highlight examples of scientific achievements that were done collaboratively.

Distribute attention

- Ask a female student a question in front of others when you know she has the right answer.
- Distribute your attention to students during class discussions. Make sure all students can participate and that male students don’t dominate the discussion.
Set the tone

YOU MIGHT SAY:

- “If you’re ever struggling in this class, here are the resources available: me, your classmates, office hours, group study sessions, second-chances on work, etc.”
- “Every year students say they can’t do this, but every year they succeed. I know you’ll succeed too.”
- “This is a challenge but being able to do this means we’re all ready to move on to the next chapter. It’s hard, but I know you can all do it.”
- “This is a very challenging task. I want you to try, even if you think you won’t get it right. I’m not looking for right answers; I’m looking for risk-taking.”
- “Give it a try–we can always fix mistakes once I see where you are getting held up.”
- “I like how you used that in everyday terms. Will you share it with the class?”

Student Story

“...he says that we’re all capable of doing physics, but we’ve just got to put our mind to it...like he’ll see us as a physics person...”

Teacher Story

Recognize students who improve even when it’s not an A. For example, I celebrate the “jumpers,” such as when a student goes from a D to a C/B.”
I assigned a vector scavenger hunt every year, where students had to figure out the end point of ten successive vectors. Every year the class would be surprised because the underachieving student would finish first—because they would look for an “easy way” to solve the problem without having to do much work. Then we all talked about that, as well as about algebraic vector addition.”

**Teacher Story**

I’ve seen teachers use popsicle sticks or index cards with every student’s name and go through the whole list of names every class period to ensure every voice is heard. I added that to my toolbox.”

**NOTE:** You can refer students to the STEP UP Classroom Guidelines poster with reminders such as “Share air time equitably.”
Plan and Assess

Connect lessons to topics that resonate with students’ values and experiences, and lower the anxiety related to grades. Female students’ interests are less likely to be incorporated in physics classes, and they are more likely to feel anxious about good grades [14-17].

Plan lessons with context

- Incorporate real world physics examples related to helping people (e.g. medical/health, alternate energy, climate science).
- Connect physics to other disciplines.

Grade equitably

- Establish clear grading rules.
- Allow second chances for high stakes assignments/tests.

NOTE: The Careers Lesson has Profiles of physicists with varied careers that can give your students additional connections to physics. You can also add additional profiles to the lesson if you have a field or job that you would like to highlight to your students.
Plan lessons with context

Teacher Story

“"I highlighted the existing examples in the textbooks that connect physics to other disciplines like medicine, climate change, communication, and music.”"

Teacher Story

“"I make it an assignment for students. They have to connect the physics we are learning to a topic they like. I give them an example of how to do it by connecting physics to something I love.”"

Student Story

“"My teacher gave the class options for topics for the semester. We got to vote on what we wanted to focus on. I like that the teacher made an effort to find topics that were interesting for us.”"

Teacher Story

“"When I taught about waves and sound, I had students who played violins bring their instruments to class and demonstrate some of the concepts we were learning.”"
Grade equitably

Teacher Story

“Rubrics are awesome for keeping the expectations clear, especially for labs and projects. I go over the rubrics so that everyone knows exactly what to expect, especially if it counts for a lot.”

Student Story

“If we don’t get it after a test, we’ll go back and quiz again on it, learn more about it, and then move on. He tries to move fast but he doesn’t want to leave anybody behind.”

YOU MIGHT SAY:

• “Remember that your assignment rubric includes your process and not just your content knowledge. I care about how you did it, not just your final results.”

• “I can tell you weren’t really happy with that quiz grade. Do you want to study and then try another version of the quiz again? I know you can do this.”
Outside the Classroom

Communicate with other people who influence students outside of the classroom setting. Female students who persist in physics are strongly influenced by others but often have fewer experiences in physics for building these relationships [18-20].

Other teachers

- Encourage teachers in other disciplines (math, biology, etc.) to recommend physics to their female students.

Counselors

- Talk to school counselors to ensure they encourage female students to take physics and consider physics careers.
- Provide school counselors with information about the breadth of jobs in physics, available from a variety of sources including careers.aps.org.

Parents and family

- Share female students’ successes and capabilities with their families.
- Provide parents with information about job opportunities in physics, available from a variety of sources including careers.aps.org.

Activities outside school

- Support female students who want to start a physics club or take part in physics activities and events.
- Find out about outreach and community activities for student engagement and encourage students to participate.
Other teachers

Teacher Story

“...especially in math and science, know all the kids who have a lot of potential. I ask them about those kids and we encourage them to take physics.”

YOU MIGHT SAY:

• “Do you have a student who isn’t taking physics next year, but you think they should be?”

Counselors

Student Story

“My counselor recognized that I excelled in math and science. She suggested I take physics and helped me get the process going. I will always be thankful to her for her support and recognition of my potential to excel.”

YOU MIGHT SAY:

• “A physics background is a really good way to prepare students for many careers. Scores on the LSATs or MCATs are much higher for students with a physics background.” [21]
Parents and family

Teacher Story

I make positive phone calls instead of just negative phone calls. Some parents have never heard from the teachers about positive comments, and it really makes a difference. I do this when students are getting better also.”

Teacher Story

I organize a Science Night with tables where students do experiments, and parents observe and circulate. The parents become proud of the students while they are doing the experiments, and it is a real sense of recognition for the students.”

Teacher Story

On back-to-school night I would get index cards from parents, so I could connect them with their child. I would ask them to tell me something important they wanted me to know about their child. Later in the year, I had their child write a card to their parent about what they love about learning physics.”

YOU MIGHT SAY:

• “Your daughter is an amazing physics student and your support of her means so much for her success.”

• “Did you know that students with a physics bachelor’s degree have higher employment and salaries than other degrees? They can pretty much do whatever they put their minds to.”
Activities outside school

Student Story

To help fulfill service hour requirements for graduation, our physics teacher helped arrange for us to tutor younger kids and do physics experiments with them.”

Teacher Story

We have a big egg drop exhibition for the whole school, and women see other women who are taking physics and enjoying participating.”

Teacher Story

I started a Women in Physics club and the young women give presentations and demonstrations throughout the year during lunch periods.”

YOU MIGHT SAY:

• “How could we help other students find out why physics is awesome?”

Student Story

To help fulfill service hour requirements for graduation, our physics teacher helped arrange for us to tutor younger kids and do physics experiments with them.”

Student Story

[My teacher] was always there after school and early in the morning if we had questions, and he had many review sessions for us.”
REFERENCES


