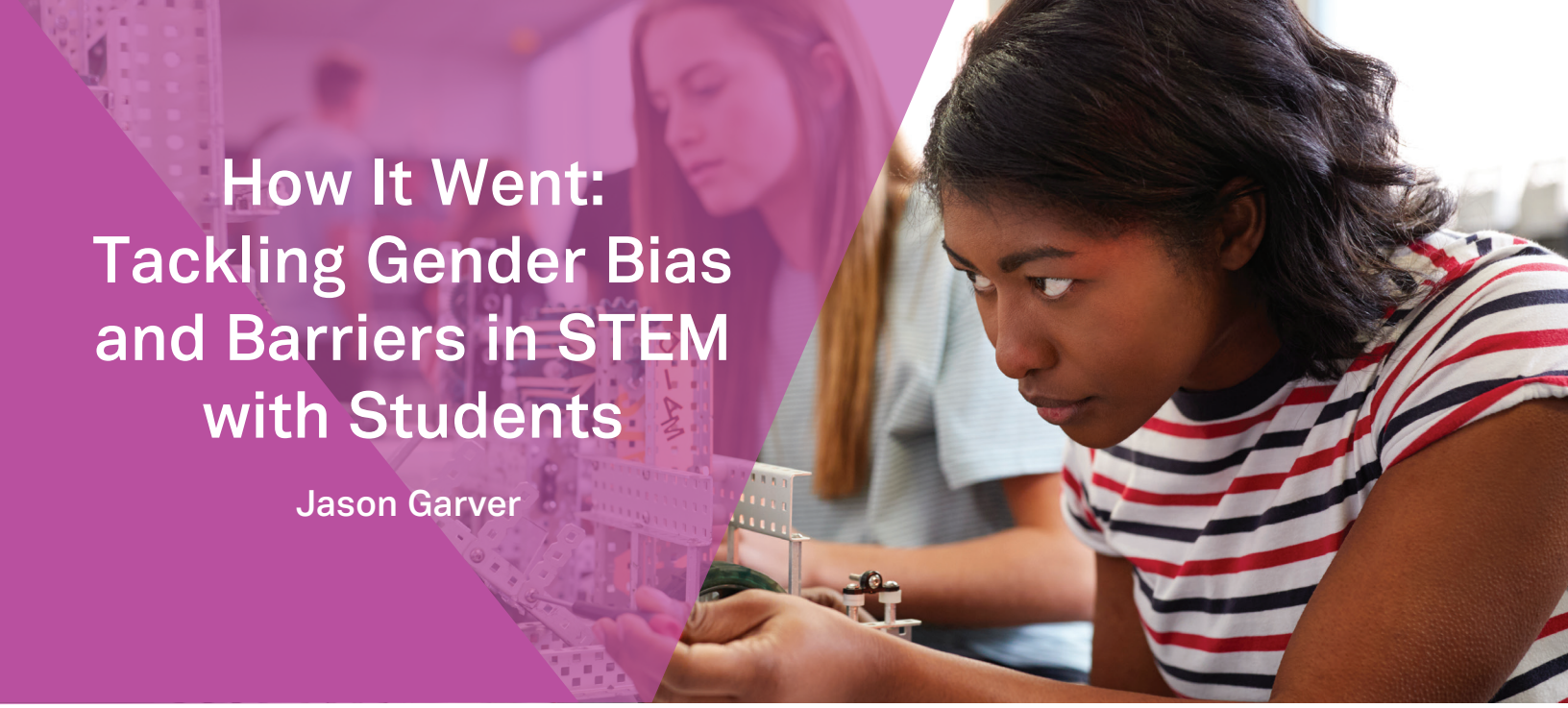


How It Went: Tackling Gender Bias and Barriers in STEM with Students

Jason Garver

Experiences integrating topics around gender bias and barriers women face in STEM into physics curriculum during the 2020–2021 school year.

What To Do During Distance Learning

Thirty-five minutes, twice a week via Google Meets that students were not strictly required to attend. That was all. Like many districts, mine had to scramble in the fall of 2020 to reinvent school and that was "class" for my students most of the 2020–2021 school year. In my context, which is a large, diverse urban school, we quickly learned that online learning presented many barriers for students as far as attending and engaging in short synchronous class sessions. Since fewer than half my students attended, I could not provide equitable access to physics content during those classes. Because of this, I shifted all instruction to asynchronous materials like readings and videos, which left all of our synchronous class time open for discussions. This left me without much to do during class, but also created a space where I would have the freedom to explore something I knew was important to both myself and students: issues related to social justice. I made the decision early on not only to provide the same 10 or so students who came to class with the chance to explore social justice topics, but all students. Many of our synchronous activities were done in a way that students could participate after the fact using different digital tools. Students were able to share ideas in discussion posts, Flipgrid videos, and Padlet posts centered around the same materials, regardless of their attendance in synchronous sessions.

I eventually came to focus on barriers women face in STEM because I recognized that those barriers were present for my students and would be exacerbated in this online learning environment. I also knew that while many of my students faced barriers in science, that few teachers explicitly discussed the problem or solutions. Our short synchronous classes needed to feel meaningful and interesting, but I did not want to punish students who could not attend so none of these activities were attached to the students' grades. What started as a three-lesson segment turned into a half-year discussion about gender representation in science, including discussions of barriers and solutions.

Data As Motivation

It is well known that, historically, women are vastly underrepresented in STEM. According to the National Science Foundation's Science And Engineering Indicators from 2018, at best, women make up only 30% of the science and engineering workforce. Additionally, in college, women can be half as likely to complete STEM degrees as compared to men (Weeden et al., 2020). Many STEM educators, especially teachers who have been trained in the last 10 years, know that there is a point during middle school where achievement in science for U.S. girls and boys begins to diverge (Rittmayer, 2008). Girls begin taking fewer STEM classes than boys and believe they are worse

at science and math; as a result, the achievement gap in these fields starts to grow. Additionally, research has shown that girls' interest in STEM throughout high school generally declines whereas the same is not true for boys (Sadler et al., 2012).

As a newer teacher, my preparation program was still fresh in my mind. Due to the knowledge and passion of one of my professors, equity, especially around race and gender, was a large and impactful part of my training. I started my career with a sense of urgency and a commitment to tackle these issues. I did things like watching my students carefully to ensure girls were able to handle lab equipment and gave students roles and procedures to ensure equity of voice and participation in group work. I tried to structure my classes to promote equity, while including examples of successful and interesting role models in addition to our science content. Yet I never felt that these efforts were connected or robust enough to combat the systemic problem in STEM.

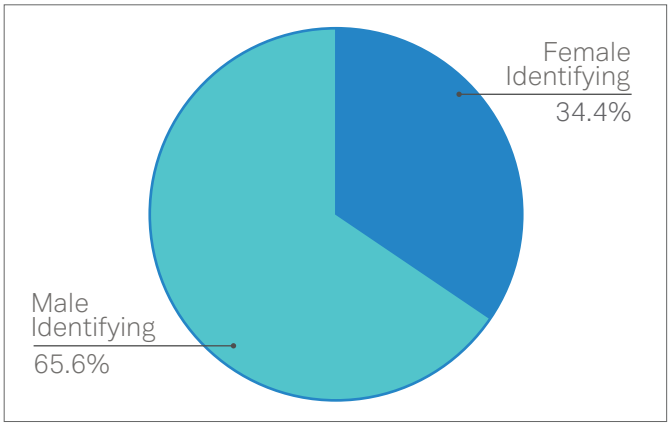
It is easy to look at nationwide data and say "not my school," which is a trap I fell into as I started my teaching career. My students come from many linguistic, cultural, and racial backgrounds, which in many ways helps to foster a natural community of equity within the school. I believed then, as I do now, that my students are inherently good, so I thought gender disparities in science would be less pronounced.

The claim that my students have an inherently more equitable experience in science than average because they have a strong community is a large one. Like any good scientist, I captured and analyzed my own data to compare with what I knew from research. In my first year of teaching, I analyzed average grades and pass/fail rates of my students by gender and saw in my classes the same results national research publications have claimed for years. Girls passed at a lower rate than boys, despite completing the same amount of work. In my second year of teaching (during the COVID-19 pandemic), I tallied the number of times students communicated during synchronous Google Meet class (speaking or typing) by their self reported gender. Girls engaged less overall, were the first to respond to a question a smaller portion of the time, and were interrupted at a higher rate than boys (see Figure 1). Just like what we see in nationwide data, there was a gender gap in achievement for my students. My belief that my students were somehow exempt from gender barriers in STEM was frankly wrong, and that did not sit right with me. I was aware of the problem of sexism in science from a historical lens, but after seeing my own female-identifying students struggling, I decided that this was something that deserved time in my class.

> *If I wanted to tackle something like gender inequity, it needed to be integrated into, not in addition to, the science content of the class."*

Figure 1

Discussion Engagement Over 20 Class Sessions



Note: This figure displays data taken during the author's synchronous Google Meet classes in the 2020–2021 distance learning school year.

The Beginning Of My Journey

At the start of my second year of teaching, I asked my students what they cared about. They overwhelmingly responded with ideas about social justice, equity, and liberation from racism. Even as a new teacher, I was no stranger to integrating social justice into physics education. In my first year of teaching, my students explored the number of citations given for running red lights from automatic traffic cameras, which disproportionately affects inner-city, low-income communities. Using their knowledge of motion, they not only predicted more appropriate yellow light durations, but also discussed what effect this could have on communities. Through this successful series of lessons, I developed the belief that if I wanted to tackle something like gender inequity, it needed to be

integrated into, not in addition to, the science content of the class.

As I transitioned to teaching several synchronous online classes at the beginning of my second year of teaching during the COVID-19 pandemic, it occurred to me that I was not satisfied with the steps toward greater equity that I attempted previously. As a classroom community, we were not addressing equity issues outright and I was throwing in mostly unrelated "token scientists" in an attempt to show girls they are represented. Equity in STEM education is serious business, but I knew I wasn't taking it seriously unless it was integrated into my practice.

I knew I just needed to jump in; instead of adding some discussion about women in STEM to my physics lessons, I needed to center the lessons around these equity issues. I was not quite prepared for the effect it would have on myself and my teaching practice, or how impactful it would be for students.

The Fundamental Difficulties

I want to preface my experience in integrating equity issues into the curriculum with the fact that I did not know what I was doing, though I did have some key background knowledge. I knew that girls face barriers like stereotype threat, which can have solutions, and that girls, LGBTQIA students, and students of color have more success when they see themselves represented in science. I knew that not all students believe they can do science, and that a history of oppression and systems that support oppression were the cause. I also knew that as science educators, it is ultimately up to us to change those systems and feelings about who can do science.

I started in a relatively simple way: we would learn about forces in the context of rocket science while taking a historical look at the progression of women in the National Aeronautics and Space Administration's (NASA) astronaut program. There was just one problem, none of my teacher preparation training, or my masters of education work, truly gave me the pedagogical skills I needed. In other words I lacked the practical "how." So I again turned to the data.

In particular, I wanted students to analyze how the number of female astronauts selected for each class in the history of NASA's astronaut program changed over time as a way to tease out their ideas about gender inequity. The trouble was, after half an hour of searching, I could not find the numbers—at least not in a usable or easily accessible form. I spent another half an hour clicking through the NASA astronaut classes starting with Mercury 7 in 1959, all the way to today, to tabulate the gender of the astronauts. Then the data needed to be graphed in an appropriate way for students, before I could even start any lesson planning. This process, making only the first lesson of a three-week series, took me around two hours to complete. At many points during this planning, I wondered if it was worth all the extra time and effort for something used in a single class period.

Therein lies the difficulty: integrating social justice into science curriculum takes time that teachers don't have. It wasn't just the first dataset: later when I looked for good videos of Sally Ride and Mae Jemison, two of the most famous female astronauts, I was at a loss. Many videos were low quality or did not include subtitles, or were otherwise structured in ways that would not be accessible to my students. Not only was it difficult to find materials, but I also found it difficult to figure out how to present material and guide student discussions in an authentic way. Quite frankly the whole process was laborious and frustrating, and took more time than any of my content planning ever has.

My Anger

There was a particular breakthrough moment for me that shifted my perspective and caused me to feel angry in a way that provided newfound purpose and energy. In addition to having students analyze data and discuss possible reasons for the shortcomings of society, I highlighted women in the history of NASA who made amazing contributions. After the frustration of developing materials subsided I felt pretty good about the direction we were heading, until I put together a lesson about Margaret Hamilton. Margaret was the director of the Software Engineering division at the Massachusetts Institute of Technology (MIT) Instrumentation Laboratory, recipient of the Presidential Medal of Freedom in 2016, and among other things is often credited with coining the term "software engineering." As impressive as this sounds, if you search for "famous software engineer," on Google, Margaret Hamilton is listed below many men I have never heard of.

Margaret also developed the onboard flight software for Apollo-era NASA missions. A working mother in the 1960s, she often brought her young daughter to MIT on the weekends and on one such occasion, her daughter crashed a simulator by pushing a button. Margaret wondered how the onboard computers could handle errors created by, for instance, an astronaut inadvertently bumping a switch. It was not long after NASA told her that "astronauts are trained never to make a mistake" that on the Apollo 8 mission an astronaut made the same error Margaret's daughter had. Because of Margaret's foresight, the error was

quickly handled and the mission continued. A change in my thinking started to occur; I stopped thinking about her as a successful female scientist and instead as the software engineer who had extraordinary foresight that allowed humans to walk on the moon in 1969, making her one of the most impressive scientists I can think of.

The fact is, Margaret Hamilton pioneered the field of software engineering and played a major role in getting humans to the moon, despite barriers she faced from society and her colleagues in male-dominated engineering. Yet unlike the other heroes of the Apollo era, Margaret is not a household name. In 1969 during the first moon landing, the craft containing Neil Armstrong and Buzz Aldrin had only 30 seconds of fuel left when the onboard computer became overloaded by errors. Their savior was a program made by Margaret that would allow the computer to relay important information to the astronauts so they could successfully land on the moon. Stories like this are all too common, where there are extraordinary people left out of the history of science. I felt angry that interviews with the first American woman in space, Sally Ride, focused on her gender and not her achievements as an astronaut and physicist. I felt angry because my students are still facing the same barriers that Sally Ride and Margaret Hamilton did and that countless other women in STEM have faced. This is the anger that motivated me to turn my "three-week segment" about gender in STEM into a focus for the rest of the school year and to continue this work even after distance learning was over.

Impostor Syndrome

Drawing on my anger and newfound motivation, I quickly shifted gears from a brief historical perspective on women in NASA, into a full focus on barriers that people face in STEM based on their gender, race, or sexuality. Instead of presenting Sally Ride or Margaret Hamilton as role models, we used their stories to identify attitudes and barriers women face in STEM. However, I wanted to connect these large scale trends to the very real barriers my students face every day. There was just one problem: me. As a cis, white, straight, English speaking male, I am not representative of my students. We know from research that when students have teachers who reflect their identity, they have better outcomes than those who don't. Therefore, I did not feel like I was the right person to do this work. I did not have specific training or lived experience with this kind of oppression and, in fact, I benefit from the systems that create the oppression in the first place.

It wasn't until I made a lesson where students would identify times they felt impostor syndrome that I realized that I felt like an impostor. I was uncomfortable making every lesson concerning gender in STEM and worried that I would use the wrong terms or that my data or anecdotes were not exactly correct. When I wanted to have students discuss a video that talked about NASA's famous confusion with the number of tampons Sally Ride needed for a few days in space, I felt the need to ask a female coworker if it was appropriate for 11th and 12th graders. I didn't feel qualified to talk to my students about barriers women, people of color and members of the LBGTQIA community face in STEM. A mentor of mine said, "If you don't do it, how will they learn?" which is especially impactful considering I am the last science teacher many of my students will ever have. I had to do exactly what I was teaching my students to do; identify that I was feeling impostor syndrome, and use strategies to separate my feelings of inadequacy from the reality that what I was doing was better than nothing.

Bringing In The Cavalry

Something that always bothered me about providing students with representations of women in STEM was that it felt disconnected from real life and inauthentic. Sally Ride is not a figure my students grew up with, and she does not represent their local and immediate culture. Although I felt like an impostor, I knew people much more qualified than myself who could help. I asked a group of colleagues that I met during my teacher preparation program if they would be willing to share their experiences as women in STEM with my students. I didn't provide any guidelines and the resulting stories my colleagues told in their short 10-minute videos were unparalleled to anything I had used previously.

One of my colleagues told the story of how she overcame feelings that she was an impostor by leaning on her support system, after a professor in college couldn't believe that she met the requirements to be in a selective advanced biology course. Another spoke about struggling as a physics undergraduate, where she gave my students a key piece of advice: just because you struggle or fail, that does not mean you can't do science. The next was a colleague who explained how she was passionate about marine life. Her college advisor condescendingly told her she would never become a marine biologist since her grades weren't perfect and instead she should go into the more suitable field of nursing. That colleague ended up traveling around the world doing research for the National Oceanic and Atmospheric Administration and other marine biology groups, despite her advisor's words. Yet another colleague outlined the painful harassment women can face in male dominated fields like veterinary medicine, and how even a good support system might not be enough.

I was appalled at what these women, my friends, went

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through. Just like before, I was angry about these experiences that would have never happened to me but certainly could happen to my students. I also felt a strong sense of pride to know these women; not only did they do really cool science and have become exceptional secondary science teachers, but that they did so given so many challenges. This was one of the first times that I felt hope that things could change, but not without a lot of work.

Student Reactions

At this point the reader may be wondering, what did the students think about all of this, how did they engage, and how did their views change? When I initially told a few colleagues and mentors that I was planning to facilitate these discussions with students I got warnings that students might not act appropriately. After all this is not something they have a lot of experience discussing, and there was the very real possibility that students might make inappropriate comments or otherwise handle themselves in ways that could become more harmful than helpful.

When we learned about NASA's lack of spacesuits that properly fit women, many of my students were flabbergasted. They made short reaction videos on Flipgrid, where an anger similar to mine came out complete with some not totally school appropriate "expressive language." It was incomprehensible to my students that an agency like NASA postponed the first all-female spacewalk because it "didn't have enough spacesuits" when it had the resources to literally travel all around the solar system. When we discussed the differences in questions asked during TV interviews with female scientists versus male scientists, students' jaws dropped, signified by the "astonished face" emoji that filled the chat. Students expressed on anonymous Jamboards how idiotic this discrimination is and how it's based in bias and outdated thinking.

As the initial confusion and shock faded, students' weekly written reflections illuminated much more personal feelings. Students wrote that they felt the same feelings of impostor syndrome and stereotype threat as my colleagues in the videos they watched. After discussing the inequitable use of materials in science classes, some students, who identified as male, realized they had participated in that behavior and wondered how to apologize, sort of lost in a hazy guilt. In group discussions, students started to leave space for their classmates and on more than one occasion, explicitly monitored who already spoke and who had not without my guidance. We learned a lot through our difficult discussions, but there was something I didn't have to teach my students: the openness to having these conversations and motivation to instigate change in themselves, the school, and the world.

At the end of the year, one that was marked by a terrible pandemic and the killing of George Floyd that sparked protests against racism quite literally in their backyards, my students reflected on what was most important to them. It was not my clever use of online games in teaching about electric charge and it was not my flexibility in due dates that stuck with kids. The most common answer across the board was the heartfelt appreciation for bringing issues about gender, race, and sexuality into the spotlight as we learned science. Not as an extra topic, but as part of the class.

Just The Beginning

I am not an expert in teaching social justice, or issues relating to gender in STEM. Teaching students about the barriers people face in STEM was not easy, and I was not the best person for the job. I frustratingly clicked through Wikipedia pages to tally the gender of astronauts, I made presentations about stereotype threat that I was unsure about, and I awkwardly facilitated discussions about how NASA struggled to figure out how many tampons a woman needed for a week's journey into space. I spent more time planning these lessons than the actual science content, but seeing emails from students after graduation thanking me for including this work makes it all worth it.

If all of that wasn't enough motivation to keep this going, the last day of school this past spring was. It was the beginning of June on the last class of the day

where I presented a slide I made at the last minute to introduce a few LGBTQIA scientists for the start of Pride month. A ninth-grade student stayed after class to thank me for representing what she called "her community," because none of her other teachers had done so. That is all the motivation I need as an educator to continue to learn and bring issues around gender, race, and sexuality into my curriculum. My mentors were right that if I don't do this, who will?

Although this all started because of the space distance learning provided, if anything I am more excited to continue this work when we're all back fully in-person. The barriers women face are just one narrow, incomplete slice of the discrimination people face in STEM that leaves out people of color and members of the LGBTQIA community. I have plans to extend this work to include race, non-binary gender, and sexuality, and the barriers those groups face in STEM moving forward. If I learned anything teaching through the 2020–2021 year, it's that there are many social justice issues which are important to students, and watching them struggle and talk through barriers women face in STEM has only shown me that they can tackle those issues. This coming year, we will explore climate justice and solutions, systemic racism and classism, and pandemic misinformation using physics as our vehicle. Not as additional topics, but again as important issues integrated into the science curriculum.

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Jason Garver,

a 2019 Knowles Teaching Fellow, is a ninth-grade science and 11th/12th grade physics teacher at Harding High School in St. Paul, Minnesota, who is passionate about tackling difficult issues in STEM education. One of Jason's main focuses as an educator is to use data and storytelling to guide students in the physics classroom in solving societal problems. Reach Jason via email at jason.garver@knowlesteachers.org or on Twitter at @AstroJasonG.