

Building Physics Identity and Belonging for Women: Re-thinking the Teaching and Learning Environment in Physics

April 5, 2025

Chesapeake Section of the American Association of Physics

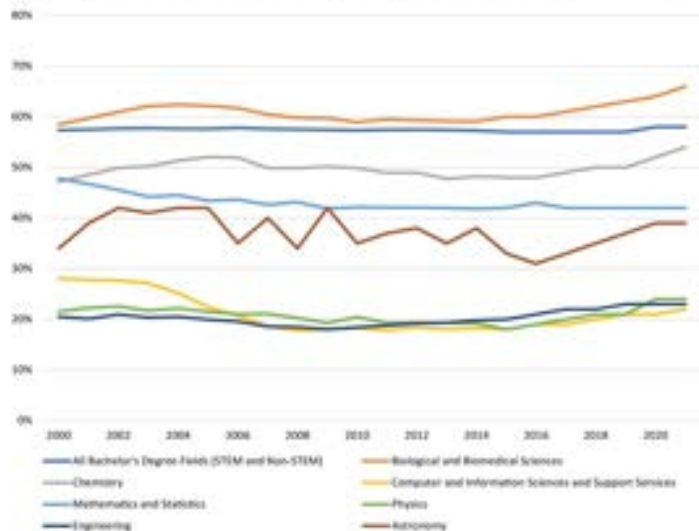


Laura M. Akesson, Julia Lipman,
Nancy Holincheck, Jessica L. Rosenberg,
Benjamin W. Dreyfus, Rocio Quiroga
Velasquez

George Mason University

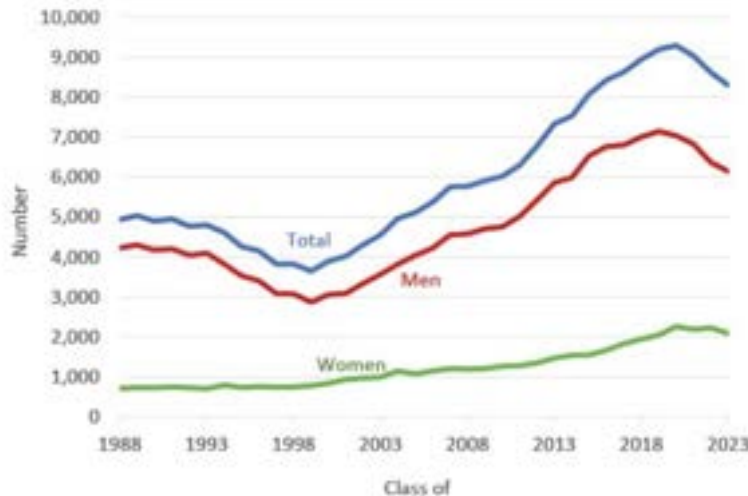
Women in Physics

Percentage of Women Earning Bachelor's Degrees Across Science, Technology, Engineering, and Mathematics (STEM) Fields, Classes 2000 to 2020



Source: The National Center for Education Statistics

Number of Bachelor's Degrees Earned in Physics, Classes 1988 through 2023



Physics departments reported <1% of their physics bachelor's degree recipients in the class of 2023 identify as a gender other than man or woman.

Data Collection

22 Years of High School Teaching

Survey recruitment

Conference for Undergraduate Women in Physics (CUWIP) attendees



120 Survey responses

Survey: Multiple choice and short answers related to participants' experiences, beliefs, and future plans



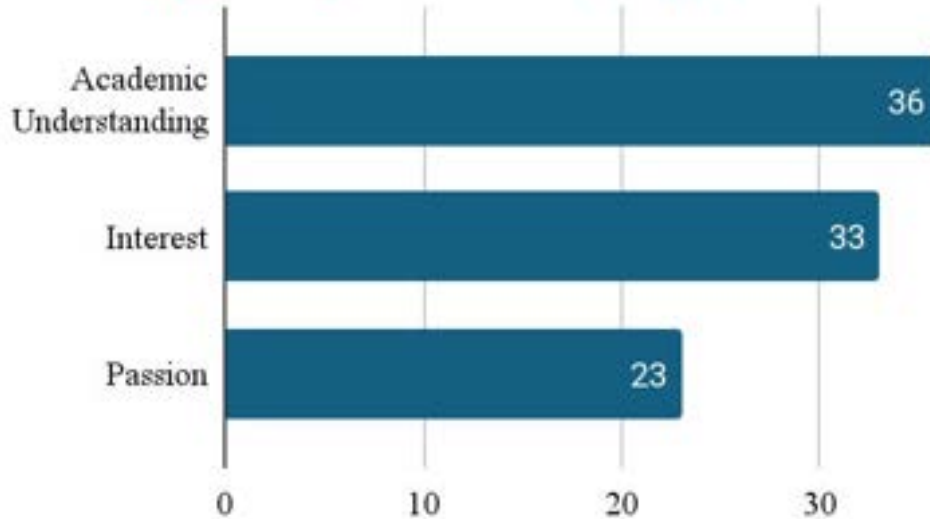
15 Interviews

1-hour Zoom Interviews



Survey Data: “What does it mean to be a physics person?”

Defining a Physics Person (top 3)



Understands physics, academic work -- may address **intrinsic/natural abilities**

Indicates they are interested in physics content, **enjoys doing or studying physics**

Sense that a physics person feels **strong emotion** for physics, at times **to the exclusion of other things.**

Survey Data

“Which picture below best describes the current overlap of the image you have of yourself and your image of what a physics person is.”



A



B



C



D



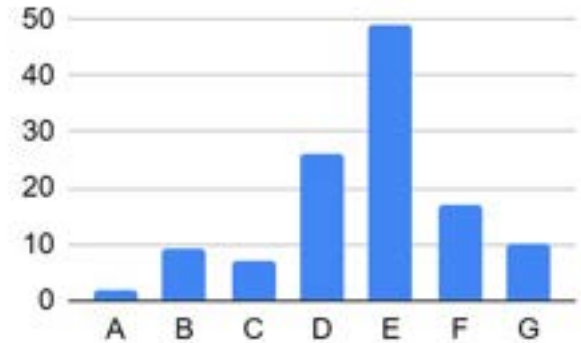
E



F



G



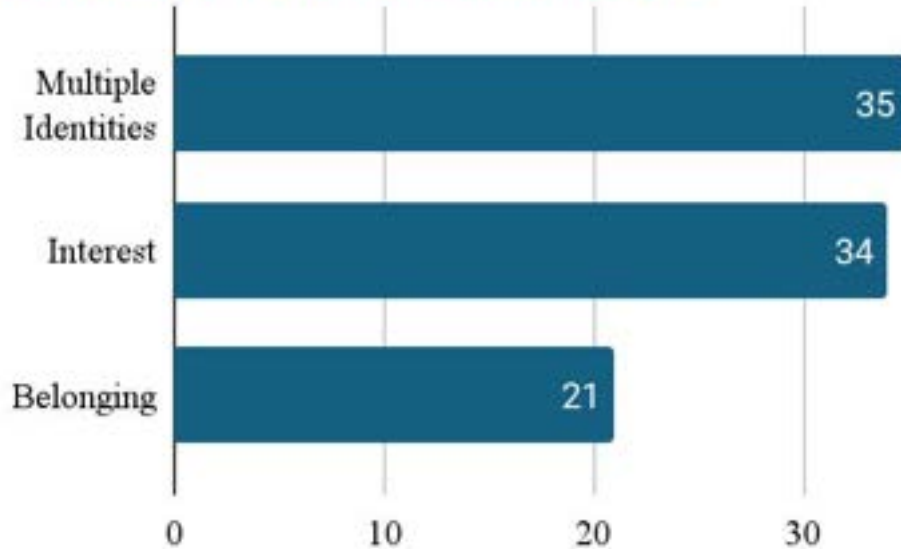
Distribution of 120 responses

Adapted from McDonald et al., 2019

Survey Data

“Briefly explain your response to the previous question.”

Self-identity explanations (top 3)

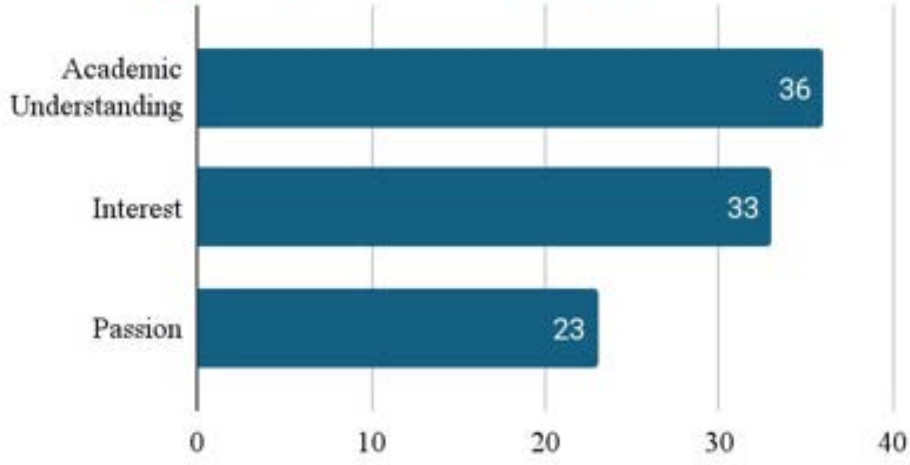


Recognition that **physics is one of multiple identities**, or multiple interests

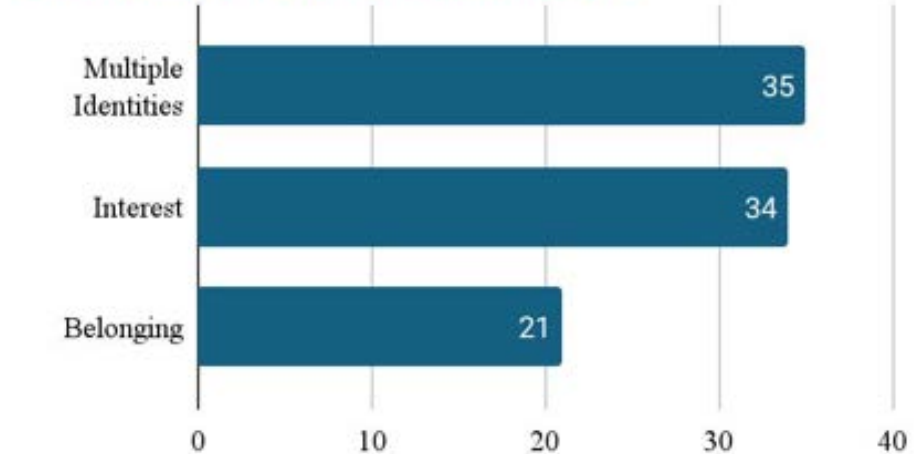
Evidence that they display **interest or intrinsic curiosity** about learning, doing, and applying physics

Perception of **fitting in the disciplinary (Physics) community**

Defining a Physics Person (top 3)



Self-identity explanations (top 3)



There is a gap between how undergraduate women defined a physics person and actual identities and designated identities

Physics Person definition



Self-identity explanations

⇒ Persistence
Belonging ↓

Interview Data



Multiple Identities

“What gets me is that I know that there's **a lot of things that I'd like to like eventually fulfill.**

And like one of that is being...a **scientist**, being an **engineer**, doing something like making and doing hands on things...I also care a lot about people...**writing** and making things accessible.

So I've thought about, like, **careers in science writing**, or maybe even someday, like, **policy...**

I've also definitely thought about **teaching**, but I think it's just me holding myself back because I really want to be a good teacher.” -Senior



- Multiple Identities are not normalized within the Physics community.

“...my passions are divided, I'm very interested in astronomy, I like **stars**, I like **old things**, and I also really like **culturally old things**. I like **dance**, I like **ballet**, I like **art**, and **I don't really see a lot of that**, or at least I'm not reaching out to enough people who are.” -junior

Interest

“I just know that I always just really liked math and science in **elementary school.**” Junior

“...with the teeth brushing, they would do this every year in my **elementary school**, they had a giant mouth that you could walk through and when you're that little, it reminds you of Miss Frizzle and the magic school, and you're taking a trip through the mouth, so they **brought science to life at an early age** for me.”
-Sophomore

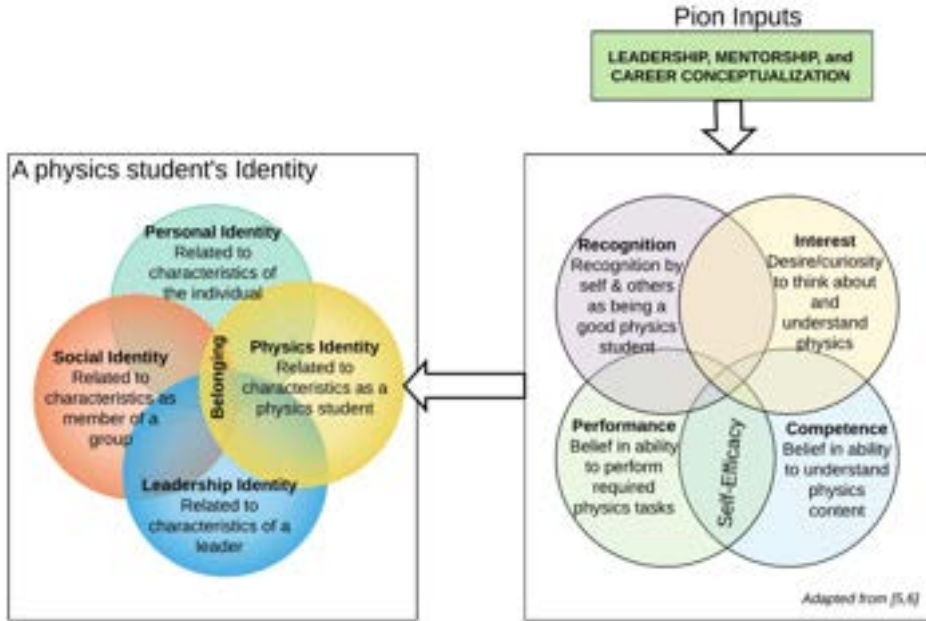
“When I took **high school physics** and I was like, wow, **this is like math but better.**” -Junior

“I had really great experiences in **high school.** ... There were a lot of women in them. And I like, felt really comfortable. And...**my junior and senior year physics teacher**, he was really, really **encouraging** and he, like, [was] able to just kind of **foster a love...for the content and like what physics was.**” -Sophomore

“STEM teachers in **high school** that kind of helped me sort of realize **that this is a space for me.** This is what's allowed for me. And those were **female, like, physics teachers** that were kind of, you know, honing in on that sort of belonging for me. - Sophomore

...building STEM capital...

Belonging in Physics



From Rosenberg et al., 2024

So, right off the bat, it's kind of back to that whole **I'm not a gifted kid** thing. Like, I ...feel like I'm not at the level that everyone else is at. ...I see a bunch of underclassmen...I'm a junior ...they ask all these really engaging questions instead of the very front row like super engaged...They say that they're struggling whenever I, if I see them at SPS... And it's like, it's so hard. I'm struggling a lot...I'm kind of privately reading, doing the readings, taking my notes, highlighting, underlining, trying to get the gist. I go to lecture, I get some more of the gist, and then I just kind of work on the homework, and then get help with my friends, and **get probably like mediocre grades**. I'm putting in the work that I can, and I guess it's paying off, but I don't know what I can do differently. Whereas all these younger kids are like, they're doing everything, **they're getting A's**, which is great for them, but **I'm just not like them**." -junior

Belonging in Physics

“Getting to know my professors really well. That's definitely helped me feel welcome and valued. They're all **very supportive of what we're doing inside the classroom and outside of the classroom**. They encourage people to **get involved with research** as early as they wanna be. So I started my research at the beginning of my sophomore year. I joined the team at the end of my freshman year and that also **connects** you with the, with a couple different upperclassmen to get to know as well. Cuz you get to see the rest of the research team and you get to see what they're going, like, what they're doing in like the upper level classes...**Really helps, like bring the community together** and like we host ...help rooms like every night and that's, it ends up being more like study sessions between the different physics majors. So that really helps bring the community together. **My professors really being there and wanting to talk to you and help you with whatever's going on** and just. Yeah, talking about your life that, **that really makes, it makes you feel welcome**. -Junior

NOT Belonging in Physics

“I'm a bit of a **spiteful person**. So I think that's a lot of my motivation...has been really, really fulfilling, not just for myself, but also just, I'm **glad that I can kind of prove these people wrong.**” - Sophomore

“I'm happy that I am a woman. **I'm an African American woman.** And I'm from America. I'm happy to do physics because of those reasons. That's what makes me more motivated, 'cause **I don't think we have that much representation.**” -Sophomore

Interview Data



“And as soon as I took on sort of that leadership role, I sort of **started seeing myself as not only responsible**, but also like **empowered** to have an influence on the experience of other undergraduates and like provide opportunities and share resources. And so I'm really motivated to, to sort of **serve my community**.” -Senior

“Being given **opportunities to help people** to like help people learn has helped me feel valued, being able to **be a mentor for younger students**, being a board member on the **Women's Days Club**. Also having people just reach out to me and be like, Hey, you wanna work on homework together? And that **individual one-on-one experience helps me feel valued and welcome**.”
-Senior



What can be done?!

- **Introspection** (re: pedagogy, classroom environment)
 - Active Learning doesn't matter (and may actually be detrimental) if equitable learning environment expectations not set
- **Knowing your students**
 - Conversation and Invitation
 - Opportunities for leadership
 - Opportunities for mentorship (ex. research)
 - Provide STEM capital
- **Recognition and peer interaction**
 - Create opportunities for community
 - Normalize Multiple Identities

“...there was 1 instance where. We were having to, like, measure something with a ruler, a ruler, a tool that we've known how to use since elementary school. And I was like, you know, getting in there is like a very precise measurement. And I had one of my lab mates, I was working with two men, he snatched the ruler out of my hand as I'm, like, quite literally using it.

And he was like, do you even know how to use this? I was like, it's a ruler, why would I not? Know how to use this and then he went into this whole thing about how you're supposed to measure it from like the very end, which was crazy because then he was wrong.” - junior

It's just nice to kind of have someone tell you, you know, that you are capable of doing those things because sometimes you can kind of lose sight of yourself, but especially when there's so many people that. For no reason, don't believe in you and make it very known that they don't believe in you.

“...in my normal day to day life, I present very femininely. ... And. I show up to my classes wearing such things. I show up to my labs wearing such things because I'm allowed to, it doesn't hinder anything about my ability to do science whatsoever. But what it does hinder is people's perceptions of me. Because if you look like a girly girl, you clearly are stupid. - junior

he really does care about his students. I mean, he came and gave a guest lecture on his own time when he didn't have to at an SPS meeting. And then at office hours, he was willing to break down homework questions for us, very patient, very helpful, got on the blackboard and was like, all right, first come first serve, let's do this. -junior

Why identity matters

- Gender differences in science identity are evident beginning in late elementary school (Carlone et al., 2014).
- Students with a strong science identity are more likely to:
 - choose a science career (Stets et al., 2017)
 - persist in STEM courses and careers (Carlone & Johnson, 2007)
- Students who leave STEM are *not necessarily* less competent (Seymour & Hunter, 2019).
Instead, the culture of undergraduate science departments and classrooms fails to cultivate science identity in some students (Trujillo & Tanner, 2014).
- In recent years, the connection between STEM capital and STEM identity has demonstrated that a variety of experiences can contribute to students' STEM identity (Archer et al, 2015)

Socialized Gendered Differences

1054

Diekmann et al.

Table 3. Resulting Goal-Endorsement Factors: Agentic and Communal Goals

Agentic goals ($\alpha = .87$)	Communal goals ($\alpha = .84$)
Power	Helping others
Recognition	Serving humanity
Achievement	Serving community
Mastery	Working with people
Self-promotion	Connection with others
Independence	Attending to others
Individualism	Caring for others
Status	Intimacy
Focus on the self	Spiritual rewards
Success	
Financial rewards	
Self-direction	
Demonstrating skill or competence	
Competition	

Note: A factor analysis of goal-endorsement items supported two distinct factors: agentic goals and communal goals. Cronbach's alphas indicate high internal consistency within each scale.

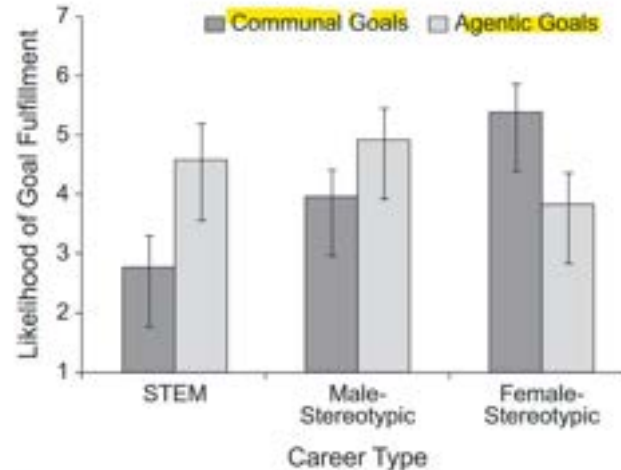


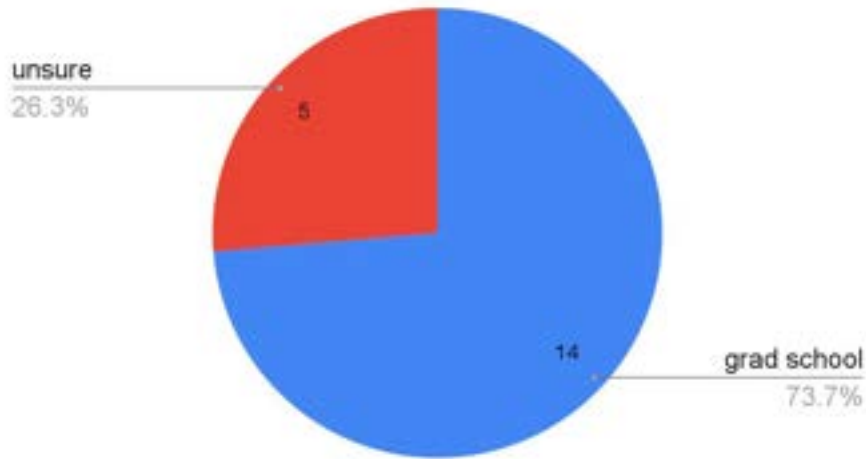
Fig. 1. Participants' mean ratings of the likelihood that communal and agentic goals would be fulfilled by science, technology, engineering, and mathematics (STEM) careers; male-stereotypic careers; and female-stereotypic careers. Error bars reflect standard deviations.

For URMs: Connections between interests in STEM and their racial/ethnic backgrounds and communities

For women: communal goals of greater importance. (Diekmann et al. 2010)

STEM capital and STEM habitus

Future Plans (Parents in STEM)



Future Plans (neither parent in STEM)



“...parental attitudes to science were found to be more closely related to children's science aspirations than general parental involvement.” Archer et. al.

Research and Stories



People and Science Stories at the National Labs