Q&A: Marty Baylor enhances students' skills and their sense of belonging as physicists

The teaching framework she has developed makes students feel at home in physics and prepares them for the workforce.

Before Martha-Elizabeth Baylor went to Kenyon College in Ohio, she was planning to study paleontology. When she got there, though, that major wasn't an option. "I identify as first generation, and I didn't know anything about college," she says. During high school, she had done an internship at NASA's Goddard Space Flight Center—not, she says, because she was interested in the program but because "my mom was like, 'It's a paid summer opportunity, you are going to do this.'" When Baylor had to pick a new major, she turned to physics.

After she graduated in 1998, Baylor spent a few years teaching middle and high school physics and working at NASA Goddard. She then went on to earn a physics PhD in 2007 from the University of Colorado Boulder.

Now a physics professor at Carleton College in Minnesota, Baylor teaches and does research on optical signal processing and photopolymers. Over the past few years, she has developed what she calls the Practicing Professionalism Framework, through which she weaves skills and confidence-building into her courses to benefit students in their working lives. One aim is to change students' perceptions so that they see physics as a cooperative, communal space where people have multiple interests. The approach, she says, can be adapted to different curricula and teaching styles.

PT: How did you choose to pursue optics?

BAYLOR: I was taking microeconomics, and I really hated the professor. He was mean. I wanted to do an independent study where physics destroys microeconomics. A physics professor mentioned having seen a nitrogen laser in the basement and said, "Why don't we see if we can get it working and then burn a hole through your economics book?"

It was a pulsed laser that had been built by a student in the 1980s and was gathering dust. I got it working, but it caught fire. I ended up throwing my economics book into the fire before putting the fire out.

I didn't know this would stimulate my career in optics.

PT: You taught school and worked at NASA before going to graduate school. Tell me about that.

BAYLOR: Toward the end of my time at Kenyon, I had a mental health breakdown. I dropped all courses except those that I needed to graduate, so I had some gaps. After I graduated, I needed time and space to recover. I got a job teaching middle and high school at a private school in Washington, DC. During the two years I taught there, I put my life back together and decided to apply to graduate school.

First, I went to NASA for two years. I did some really cool stuff. I worked on LISA [the Laser Interferometer Space Antenna, a planned mission to detect gravitational waves in space], and I was involved in designing star trackers for attitude orientation of spacecraft. I worked on *JMEX*, the *Jupiter Magnetospheric Explorer*, a telescope to study auroras on Jupiter, and I built an optical test bed to select between programmable slit technologies for the near-IR spectrometer on the *James Webb Space Telescope*.

While at NASA, I spent my evenings and weekends teaching myself what I needed in order to do well enough on the physics GRE to be able to apply for grad school.

PT: You've lived in China. How did that come about?

BAYLOR: The engineers I worked with at NASA when I was in high school were doing a joint project with Japan, so I thought I'd study Japanese for my language requirement. But when I got to Kenyon, the music presentation at orientation conflicted with [the presentation for] Japanese, so I went to the presentation by the Chinese department. I really liked the professor, so I stayed in Chinese. I studied at Nanjing University for a semester.

At the time, my department chair told me I shouldn't go, that it was more important for me to prepare for graduate school. But I thought I might never have the opportunity again. I declared Chinese as a minor so that my academic adviser—a different professor in the physics department—could sign the form. She was supportive.

Later, as a graduate student at an NSF IGERT [Integrative Graduate Education and Research Traineeship] program in optical sciences and engineering, I had to do four rotations—three in labs plus an

MARTY BAYLOR (Photo courtesy of Carleton College.)

internship. I arranged for my internship to be at a laser company in Shenzhen, China.

My experiences in China are a connecting point between me and my students. Not only can I speak to my Chinese students, but I also show students that it is OK to study abroad in a non-English-speaking country and do something other than physics. My experiences in China still very much shape who I am today.

PT: What attracted you to academia, and what was your path to Carleton?

BAYLOR: My passion is teaching. I will do it in a grocery store checkout line. After I got my PhD, I was a visiting professor at Carleton for part of a year. Then I went back to Boulder and did a two-year postdoc. In 2010, I started a permanent position at Carleton, and I've been here ever since.

PT: Tell me about your research program.

BAYLOR: I typically have about eight undergraduates working in my group. We published research in which my students used interfacial surface tension between water and photopolymers to fabricate lenses. We also make integrated optofluidic devices. The students measure the difference in refractive index that you can get from different formulations of the photopolymer, which determines whether you can make a multi- or single-mode waveguide within the slab. But the pace of research is slow with undergrads.

PT: What led you to develop the Practicing Professionalism Framework?

BAYLOR: I was teaching a sophomore-level atomic and nuclear physics course, and I was frustrated by the way students were approaching their assignments. In their drive for efficiency, they were letting bias influence how they made choices, and it also meant they were not developing the skills I was trying to teach them.

PT: What's an example of those biases?

BAYLOR: In the lab, I heard students say things like, "You are the woman, why don't you take notes?" "You are Asian, you are good at math. Why don't you propagate the uncertainty?" And the white male would say, "I tinker in the garage with my dad, so I will work with the apparatus." It wasn't these exact words, and it wasn't every group, but the net effect was that, on average, women were taking notes, Asian students were doing the math, and white men were working with the apparatus. After several years of that, in 2016, I started intervening to interrupt that pattern.

PT: So that was the first step toward developing the framework?

BAYLOR: Yes. Another observation also played a role: Graduating seniors would come into my office and say, "Marty, I don't know what I am going to do with a physics degree. I don't know how to do anything."

I asked myself, How do I frame a course so that students understand what they are doing, why they are doing it, and how it connects to professional practice? How do I get students to develop the habits of mind that they need to understand what it means to be a physicist?

This shifted my thinking. I added a new dimension to how I teach. This practicing professionalism dimension is, I think, critical to broadening students' perceptions of who a physicist is and what a physicist does.

PT: Describe the framework.

BAYLOR: It has three parts. What a physicist knows, which is content. What a physicist does, the skills—experimental, theoretical, computational, analytical—that we develop in our students. And then there is what physicists care about. This third area is what motivates my career.

PT: What are examples of the third category, and how do you bring that aspect into teaching?

BAYLOR: Physicists can care about many things—history of science, outreach, public policy, inclusion and justice. When instructors try to bring these topics into the classroom, more often than not students push against it and say it's not physics.

What I started doing was, on the first day of class, after I introduce myself, I tell my students to take five minutes to look through *APS News*. While I take attendance, I ask them to share the topic or title of an article that caught their eye that was not about physics theories or apparatus.

By using *APS News*, I am showing them that, independent of me, the physics community is having conversations about other topics. When I started motivating topics with this approach, all the pushback stopped.

PT: How does the Practicing Professionalism Framework change how you teach?

BAYLOR: I lay out in a transparent way what students need to know and how they need to approach their work. I grade them on whether they are approaching their work like a professional would. This is for journal articles, homework, and exams. They are intentionally developing that "professional approach" muscle.

Most students fail their first assignments. But early attempts don't affect their grade. They need to be able to practice and fail without fear. This approach changes my relationship with the students, from being a gatekeeper trying to keep them out to someone who is doing an assessment to figure out where they are and coaching and mentoring them to get where they want to be. It's more satisfying as a teacher.

Another aspect of the framework is that I assign students roles in the lab: notebook-meister, apparatus-meister, and analysis-meister. The students rotate through those roles multiple times. By the time they are in a senior-level lab, they can work in a group more organically.

PT: What differences do you see?

BAYLOR: I have reflection essays from the students that show an increased sense of belonging. That helps the overall atmosphere: I have observed that students who feel they don't belong may withdraw with anxiety and impostor feelings. Or they lash out by aggressively challenging the teacher to show that they belong and are brilliant. Or they step on a fellow student to show how smart they are.

When they realize that a physicist doesn't have to be a lone genius who wins the Nobel Prize—it can just be someone who is interested in physics and wants to spend time learning about the world—they don't feel pushed out. They feel welcomed and can welcome others.

PT: Is that approach likely to get caught up in the Trump administration's actions targeting diversity, equity, and inclusion [DEI] efforts?

BAYLOR: When I was creating the Practicing Professionalism Framework and named it, I never viewed it as a DEI intervention. It's a way of broadening the audience, focusing on skills, and maintaining rigor. But it's not framed from a space of identity. For me, this has always been about making physics accessible to everybody. So I am not worried about it.

PT: Is there anything you'd like to add?

BAYLOR: At Carleton, my largest class is 48. I am working with colleagues at the University of Washington to explore how one might implement the Practicing Professionalism Framework in large introductory courses across STEM. If we can get over that hurdle, then we can spread the framework more broadly.

Toni Feder

Graduate assistantship pay often falls short of a living wage

The graduate student stipends offered by many US physics departments are insufficient to live on, even for students who split housing costs. That's according to *Physics Graduate Student Compensation: Academic Year 2023–24*, a recent report by the statistical research team of the American Institute of Physics (publisher of Physics Today). The report includes the analysis of compensation data collected from more than 100 public and private PhD-granting physics departments.

For first-year teaching assistants, stipends ranged from about \$18 000 to \$47 000; the average was \$30 000. For fifth-year research assistants, stipends were from around \$20 000 to nearly \$50 000; the average was \$32 700. In addition to a stipend, students often receive benefits such as health insurance and free tuition.

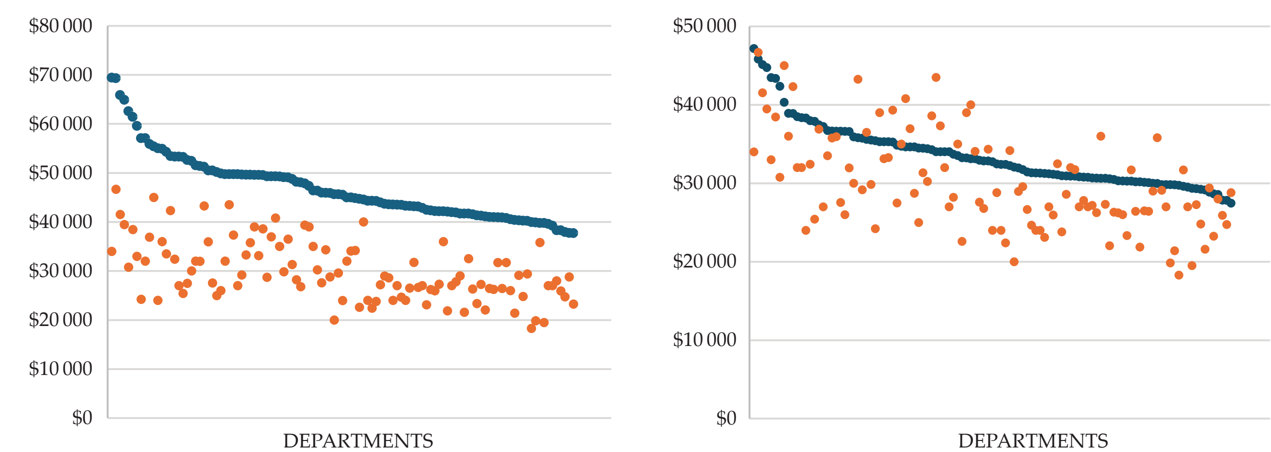
In the 2020–21 academic year, a teaching assistantship was the main source of financial support for 56% of first-year physics PhD students. In the same period, 60% of fifth-year students were employed as research assistants, which served as their primary source of income. Service hours varied, but most departments required student assistants to work roughly 20 hours a week, according to the report. Private schools typically paid more than public ones, and schools with larger graduate programs tended to pay more than those with smaller programs.

Do teaching and research assistantships provide a livable wage? The researchers tackle that question with a calculator developed at MIT. The calculator accounts for such factors as the prices of rent, food, transportation, and other basic needs for a given location. For someone living alone in Boston or New York City, for example, the living wage is around \$69 000—well above the stipend amount a physics student would receive from an assistantship. For those who live in a shared apartment, around \$46 000 would do. For comparison, in St Louis, Missouri, or Toledo, Ohio, the living wage would be about \$39 000 for someone living alone and \$29 000 for someone sharing an apartment.

The accompanying figures plot the living wage in blue, from high to low, for a student living alone (left) or splitting costs with a roommate (right) in the locations of the institutions. The typical first-year teaching assistant stipend offered by each institution is plotted in orange. All the schools' stipends shown in the left graph and three-quarters of the schools' stipends shown in the right graph fall below the blue line.

For more information on compensation for physics graduate student assistantships, see https://ww2.aip.org/statistics/physics-graduate-student-compensation-academic-year-2023-24. The Living Wage Calculator is available at https://livingwage.mit.edu.

Tonya Gary



TEACHING ASSISTANT STIPENDS for first-year physics graduate students (orange dots) fall below the living wage (blue dots) for living alone in a studio apartment in cities across the US **(left)**. Those stipends, which range from around \$18 000 to \$47 000, go further for students who share a two-bedroom apartment **(right)** but, in most cases, still fall short of a living wage. (Figure adapted from P. Mulvey, *Physics Graduate Student Compensation: Academic Year 2023–24*, AIP Research, 2025.)