Embracing interactive teaching methods FREE

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EMBRACING INTERACTIVE TEACHING METHODS

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New physics and astronomy faculty are excited about active teaching, but they still need support to implement the ideas in their classes.

If you teach, you may remember your first time in front of a classroom. You were probably nervous, wondering whether you had planned a good lesson and the students would like both it and you. You may have been excited to light up a set of fresh faces with your favorite topics or demonstrations. Whether that first day was yesterday or 20 years ago, you probably thought deeply about what to teach and how best to convey it to your students. But teaching physics now is not the same as it was 20 years ago.

Lecturing has been the predominant mode of instruction since the birth of universities, but those norms have changed. Modern physics classes often use methods that more actively engage learners. For example, to give students the opportunity to work through the meaning of physical ideas, an instructor might ask them to predict the outcome of a demonstration and talk through their reasoning with a neighbor, all before doing the demonstration itself.

Such beneficial teaching changes are largely due to the efforts of physics and astronomy education research (PAER) and the professional societies that have helped spread PAER-inspired instructional strategies and curricula. In addition to improving student education, the increased use of active learning in the classroom has also created a need for faculty to develop their knowledge and skills. The three of us and a collaborative team of PAER experts over several decades have been putting together professional development workshops for college faculty, which have helped to drive the increased use of active teaching and learning in higher education.

Luckily for today's new (and not so new) faculty, we know how to teach physics and astronomy more effectively than we used to. A broad set of research has demonstrated the value of active learning and interactive engagement—educational techniques that go beyond lectures.

Education research to the rescue

Active learning can narrow achievement gaps. For example, a meta-analysis of 225 studies found that students in traditional lecture classes were 1.5 times more likely to fail than students in active-learning classes.[1] The researchers also found that student learning, as measured by conceptual assessments, increased by half of a standard deviation in active-learning classes, and those results held across all STEM disciplines and all class sizes. Another meta-analysis of 15 studies found that a high use of active learning significantly reduced gaps between students from underrepresented and overrepresented groups (as determined by using race, ethnicity, and socioeconomic status as a proxy for underrepresentation). Active learning also reduced gaps in examination scores by 33% and in passing rates by 45%.[2]

HALEIGH MACHOST

FACULTY TEACHING INSTITUTE WORKSHOP PARTICIPANTS share their hopes and plans for teaching improvement over the next year. The look-forward exercise occurs on the final day. Check-ins with the participants will continue over the next year to support implementation of their plans.

A wellspring of results from PAER has informed our understanding of effective teaching and learning of physics and astronomy since the 1980s.[3] That work has also given rise to many PAER-informed instructional methods and curricula that can be used to teach physics concepts and skills: tutorials, ranking tasks, tasks inspired by physics education research, peer instruction, interactive lecture demonstrations, and investigative science learning environments. Details about those and other teaching methods can be found at PhysPort (https://www.physport.org).

In addition to improved comprehension, increased engagement in the classroom has also been shown to increase equity in physics. For example, Joshua Von Korff and coauthors reviewed the results of two common force-and-motion conceptual assessments taken between 1995 and 2014. They found that across 72 studies covering 600 classes, active-learning methods were significantly more likely to show high learning gains than lecture-based ones.[4] Moreover, those results held across two-year colleges, liberal arts colleges, research universities, and different class sizes. Active learning also led to greater learning for students at varying levels of incoming preparation, measured by either SAT scores or precourse conceptual-understanding assessments.

How can physics faculty get up to speed on implementing active-learning techniques? Most new physics faculty need explicit instruction on how to teach effectively. Some have never seen active learning in practice. Creating a productive class, especially an active-learning one, is not trivial. We also know that many student populations, such as first-generation students and historically underrepresented groups, too often leave STEM because of the negative experiences they have in their introductory classes.[5] To intentionally design college physics and astronomy classes that maximize student learning and promote a sense of belonging, we need professional development experiences that can help physics faculty evolve their teaching.

The New Faculty Workshop

Our professional societies have long sought to support faculty as effective teachers to help the physics and astronomy disciplines thrive. Since 1996 the flagship program to introduce new physics faculty to research-based teaching has been the annual Workshop for New Physics and Astronomy Faculty, affectionately known as the New Faculty Workshop, or the NFW. Three societies—the American Association of Physics Teachers, the American Physical Society, and the American Astronomical Society—partnered to offer the four-day workshop.

From 1996 through 2022, the NFW introduced participants to the primary findings of PAER and various PAER-based instructional materials and strategies. PAER curriculum developers and researchers presented sessions on their instructional methods at each NFW. The workshop's primary goal was to reach a significant fraction of the physics and astronomy tenure-track faculty, thus broadening the use and uptake of PAER techniques.

The NFW boasts 2900 alumni from 85% of all physics-degree-granting institutions and about 40% of physics and astronomy new faculty hires in the US. The endorsement of the NFW—and the current Faculty Teaching Institute—by professional societies conveys that our physics community encourages thinking about teaching as a scholarly activity and promotes the use of active-learning techniques. The explicit focus on physics and astronomy teaching ensures that we provide applicable advice and examples that respond to the needs of physics and astronomy teachers, which increases the likelihood that they bring innovations to their classes.

The goal of the early NFW events was to persuade faculty to try active learning in their classroom. When community leaders first developed the NFW, PAER was a relatively new field. Academia changes slowly because of the decentralized nature of higher learning and because new scholarship takes a long time to establish and gain broad credibility. Therefore, more physics faculty were unfamiliar with or skeptical of research-based teaching approaches. Part of the job of the NFW was to establish the value and credibility of PAER-developed instructional strategies and materials, including the benefits to students.


MARILYNE STAINS

ACTIVE LEARNING AT WORK. Physics and astronomy educators collaborate on a small-group activity during the June 2023 Faculty Teaching Institute workshop. They then consider how they can use the same technique with their students.

To achieve that goal, organizers arranged the NFW as a series of approximately 25 presentations, each led by an expert in a particular instructional method. The presenters spent significant time sharing evidence of improved student learning, explaining how their instructional methods intellectually engaged students and improved their learning, and modeling best practices for use in the classroom. The featured methods had well-established instructor materials and clear guidelines on implementation. Because the presentations were standalone, the parade of presenters gave participants a broad view of key developments in physics teaching.

"Active learning reduced gaps in examination scores by 33% and in passing rates by 45%."

The workshops were eye-opening for many faculty, a majority of whom then experimented with the methods in their classes. Participants reported increased knowledge of and motivation to use active learning.[6,7]

One year after the workshop, almost all participants surveyed across multiple years reported using more active learning than before the workshop, and 87% said they used at least one published PAER technique. Additionally, 96% reported changing their teaching after the NFW and attributed at least some of that to their workshop attendance.[6] Even more compelling, a large regression study found that attendance at the NFW was the best predictor of whether a faculty member would try a published PAER teaching practice.[8] Thus the NFW has been crucial in setting teaching norms and establishing a common knowledge base among physics faculty.

The NFW did have shortcomings, however, and attendance didn't necessarily lead to long-term use of its promoted strategies.[8] Alumni often reported feeling unable to use the strategies well.[7] And, troublingly, some participants reported feeling disempowered by the NFW, as though the organizers were explicitly telling them how to teach.[9] We've since realized that trying to persuade faculty to use active learning isn't what they actually need. Professional development must be faculty centered, attending to and informed by educators' existing knowledge and interests.

Today's faculty are different

New physics faculty are coming into the profession with markedly different beliefs and experiences than 20 years ago, and we realized that the NFW was no longer well aligned with the needs and expectations of that population. Evaluation results from 442 participants who attended a workshop between 2015 and 2018 showed that only 18% were unaware of the teaching methods presented in the NFW, and 80% had already tried at least one PAER teaching technique.[7] Such increased awareness holds true beyond the NFW: A 2019 survey of new and experienced physics faculty found that 87% reported using at least one published PAER technique, and most spend at least 30% of class time on active learning.[10]

Box 1. FTI long-term goals

As a result of our Faculty Teaching Institute workshops, physics and astronomy faculty will

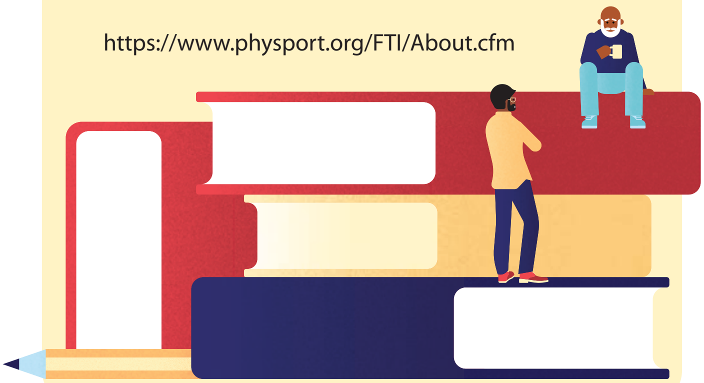
1. Value and use **student-centered and reflective practices**, and consider excellent teaching and learning to be a shared responsibility within departments.

2. Demonstrate awareness and practices that support **diversity, equity, and inclusion**, with particular attention to marginalized groups.

3. Connect to a **supportive disciplinary community** that is engaged in helping and empowering one another to evolve their approach to student-centered teaching as lifelong learners.

4. Be empowered to **navigate a fulfilling academic career**, achieving a rewarding balance among teaching, service, and research commitments.

https://www.physport.org/FTI/About.cfm



New physics and astronomy faculty today have come of age in a different culture of teaching. Research-based instructional strategies are a more accepted part of the academic lexicon than they used to be. Terms like "physics education research," "active learning," and "learner-centered instruction" are no longer unfamiliar to faculty. The favorable climate for using learner-centered teaching has helped new faculty take up—and continue to use—PAER teaching techniques. In the past, 30% of faculty who tried published PAER methods stopped using them; now only 5% stop.[10]

In light of that, it's no longer appropriate to view new faculty as skeptical novices. They aren't starting from scratch. They have existing experiences and beliefs that can be built on in a professional development learning environment—just like the one we are teaching them to create for their physics classes. As one faculty participant told us on a postworkshop survey, "We get it, we want it, so GIVE IT TO US."

How do we teach teachers?

What faculty need is to engage in experiences that help them develop their confidence and skills as educators. While new physics faculty are generally eager to use active learning, they are still in the first few years of their career. As such, they have little experience with what it takes to create an efficient and effective class. Professional development workshops are one tool for faculty support, and we now know more about how to set up faculty for success. We know that professional development can be powerful if it is discipline specific and of sufficient duration. We also know more about how to design the workshop experience.

First, faculty need (and want) good knowledge about teaching. They need an organized mental framework to guide their teaching decisions—just as our students need an organized set of ideas about physics. Faculty also need to know that all students can learn physics; they need to understand issues of equity and inclusion in the classroom.

But people need more than motivation and knowledge to adopt a new behavior—they need to feel empowered to act. People are much more likely to take up behaviors that they choose and that they feel are achievable. Therefore, the workshop needs to help faculty cultivate a sense of ownership and autonomy over their teaching, make sense of their class outcomes, and still maintain their creative control. We need to set up new physics faculty as lifelong learners.

A key part of that is supporting faculty as reflective practitioners. All learning—academic, professional, and personal—is supported best by reflecting on one's progress and improving for the future. Faculty are learners engaged in a continuous cycle of teaching development: trying something, gathering feedback, reflecting on their experience, seeking input and knowledge, and deciding on future changes that better meet their goals and address students' needs. It is, after all, the same process as developing scientific knowledge through research. Thus helping faculty learn to perceive and respond to student learning needs, including equity issues in teaching, is a vital goal.

Another important goal is to instill faculty with a growth mindset around teaching and a willingness to learn. When educators see teaching as a continuous journey of learning and growth, they can become resilient in the face of inevitable challenges.

Additionally, new faculty are in the early stages of professional careers. Teaching support should occur in the context of the larger faculty role: It should address the whole faculty member, help them navigate common issues, connect with other faculty and professional societies, and develop resilience. Now that we are equipped with that new knowledge, we are reenvisioning physics and astronomy faculty development to better meet the current moment.

Introducing the Faculty Teaching Institute

To meet the changing norms of the physics community, in 2022 the American Association of Physics Teachers, the American Physical Society, and the American Astronomical Society, with generous support from NSF, have engaged in a strategic redesign of the NFW that is focused on the needs of today's faculty. We have rebranded the workshop as the Physics and Astronomy Faculty Teaching Institute (FTI; www.physport.org/FTI). The new name better represents the comprehensive nature of the workshop and professional development experience while allowing room for the project to expand beyond tenure-track, early-career faculty.

The workshop experience of the FTI is collaboratively developed and led by the three of us and facilitated by a set of roughly five diverse and experienced physics and astronomy education practitioners and researchers. The team approach offers a more coherent experience than was possible in the old parade-of-presenters model. We developed the FTI around a set of design principles, which can be found at PhysPort (https://www.physport.org/FTI/About.cfm). One such principle is that "workshop delivery is respectful and participant-centered." The FTI instruction emphasizes that learners, including faculty, construct their knowledge based on their existing needs.

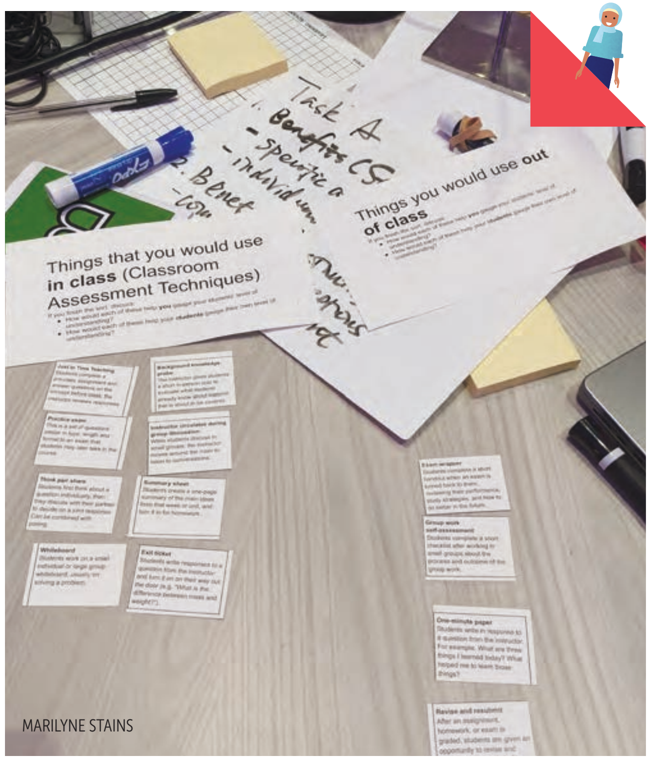
In the current design, the FTI offers a four-day, coherent interactive workshop focused on learner-centered education in an equity, diversity, and inclusion framework. Rather than persuading faculty to use student-centered instruction, the FTI aims to build faculty's agency to make their own well-informed teaching changes. It does that by providing them with a firm grounding in the principles of teaching and learning, engaging them in transformative experiences that offer deep insight into real-world student experiences, and encouraging reflection on their teaching. The FTI's long-term goals for physics and astronomy faculty are summarized in box 1.

Participants at the FTI are introduced to a wide array of effective teaching methods and assessment. That coherent "big tent" approach is a significant shift away from the previous model of featuring siloed sessions narrowly focused on specific PAER methods. Those specific methods, however, still appear as exemplars of generalized strategies.

The FTI also offers extensive postworkshop opportunities, including a newsletter, virtual office hours, and a yearlong faculty learning community.

Being a faculty member involves more than just teaching. The FTI aims to discuss how teaching is evaluated, how the tenure process works, what learning to prioritize, and how faculty members identify themselves. For example, we urge participants not to overprepare for teaching and to say no to requests that don't meet their career goals. The FTI workshop treats faculty as people with multiple responsibilities rather than focusing on teaching as yet another task to do perfectly. As our collaborator Laurie McNeil urges our faculty, they should "do their very goodest."

To help faculty engage all of their students, the FTI addresses equity and inclusion throughout the workshop. Faculty begin by reflecting on how their identities and lived experiences shape their teaching interactions. Those reflections are greatly enriched by the diversity of the FTI participants. Students with a wide range of lived experiences engage in courses differently, so specific teaching practices and structures can be used to support them. The workshop helps faculty adjust their teaching for students at risk of feeling disconnected and educates them on historic harms from schooling or science that students may have experienced.



MARILYNE STAINS

DIFFERENT ASSESSMENT TECHNIQUES to evaluate student progress can be used inside or outside the classroom. Faculty are challenged to sort the techniques (displayed on pieces of paper) by where best to use them.

The workshop content is tied together through a set of principles of teaching and learning that aid faculty in selecting thoughtful strategies and using them well. Those principles give a shorthand for understanding why different teaching techniques are effective and help educators make informed choices for their classroom. The principles, along with some example prompts, are presented in box 2.

"Research-based instructional strategies are a more accepted part of the academic lexicon than they used to be."

To further support faculty adaptation, the FTI offers multiple options for achieving any particular goal, such as supporting students' sense of belonging. The workshop emphasizes practical tips and dedicates time for working in small collaborative groups, engaging in deep discussions, journaling, and developing a sense of community with their fellow participants. Those discussions and writings culminate in each participant developing a concrete action plan to guide their learner-centered teaching experiment over the next year. Participants are regularly reminded of their action plan during the subsequent year and supported in achieving it through postworkshop engagement opportunities that are organized by the FTI.

Our hopes for physics faculty

Overall, we intend for the FTI to support participants in becoming

Box 2. Principles of teaching and learning

Prior knowledge and motivations

Connect to students' prior knowledge and motivations to leverage their powerful ideas and interests and support them throughout any struggles.

"What do you think of when I say 'force'?"

Active engagement

Use active engagement so that students make meaningful connections, because they were the ones to make sense of the material themselves.

"What do you think will happen when . . . ?"

Social interaction

Use social interaction so that students can verbalize their thinking and coach one another.

"Turn to your neighbor and discuss."

Feedback and reflection

Provide opportunities for feedback and reflection so that students can adjust their learning.

"Let's do a quick poll . . . "

Inclusive and supportive classrooms

Use inclusive classroom strategies and create a supportive and welcoming climate to strengthen learning for students from all backgrounds.

"I'd like to hear from at least three students . . . "

Scaffolding

Start simple and provide early support so that students can build skills and concepts. Then gradually step back and provide less structure.

"I've set up the problem. Now what is the next step?"

Adapted from references 11 and 12.

thoughtful, effective teachers who feel empowered to select and use techniques to create learner-centered classrooms and have a fulfilling teaching career. The redesigned workshop was offered twice in 2023 with positive results. Postworkshop evaluations showed that participants reported gains in knowledge, skill, and motivation to use student-centered practices, and 92% would recommend the workshop to a colleague.

Participants appreciated the practical and relevant content, the deliberate modeling of the teaching techniques, and the extensive collection of resources. As one participant shared, "I thought it was a great experience . . . . It was helpful to see what others were doing and to feel like I was part of a larger community who had the same struggles as me." Another said, "I knew there were better ways to teach before the FTI, so [I] had good motivation but little idea on where to start. The FTI provided that, and gives me much more confidence that I can improve my teaching using the tools provided."

Participants also appreciated the use of action planning, and all intended to carry out their action plan. "I appreciated having plenty of time to work on [my action plan] each day, which encouraged me to take it more seriously," one participant said. "I think there was sufficient time and structure to make use of it, and I appreciated how the facilitators emphasized keeping plans small and manageable."

As reflective teachers ourselves, we also learned many ways to better attend to the needs of our new faculty learners, such as improving pacing, ensuring that journal prompts are meaningful, and carefully building the action plan throughout the workshop.

Teaching physics and astronomy matters. It matters for us, for our students, and for our institutions. It has ramifications beyond what we directly influence. That is partly why new professors are nervous: They are educating the next generation about how physicists and astronomers think about the world. The FTI and the professional societies that support us are committed to helping all physics and astronomy teachers flourish. We want faculty members to experience the joy of being a great teacher and reaching students. Our hope is that by equipping them with foundational knowledge, skills, and mindsets, they will be empowered to go back to their home institutions and create effective and inclusive classrooms that are welcoming and intellectually stimulating.

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