2025 PHYSICS EDUCATION RESEARCH CONFERENCE

Washington, D.C. August 6-7, 2025

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2025 Physics Education Research Conference

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Preface

The theme of the 2025 Physics Education Research Conference (PERC) was "*A PER lens on the International Year of Quantum Science and Technology*". This theme invited attendees to explore ways that PER can contribute to the global discussion around emerging technological applications of quantum science. The organizing team, Beth Thacker, Ben Zwickl, Amin Bayat Barooni, Andi Piña, Farai Mazhandu and Will Riihiluoma, encouraged attendees to discuss the open questions and identify the opportunities for research in quantum science and technology education. The committee was supported in their efforts by leadership from both the American Association of Physics Teachers (AAPT) and the PER Leadership and Organization Council (PERLOC).

The plenary sessions featured forward-looking presentations on how we might begin to tackle the many challenges associated with teaching and assess learning in the emerging and highly interdisciplinary field of quantum technology. The plenary speakers were (in order of presentation): Bethany Wilcox and Josie Meyer; Chris Porter; Franziska Greinert; and Angela Kelly.

The conference theme was also explored in several Community Connections sessions, Parallel Sessions, and contributed poster presentations. In addition to the sessions and presentations focused on the conference theme, the remainder of the sessions and presentations represent the breadth of current research within PER. The papers published in this Proceedings therefore represent an annual snapshot of the field.

The 2025 PERC Proceedings process would not be possible without the ongoing support of Lyle Barbato, who works closely with the editors each year. The sponsorship of AAPT and open-access publishing through ComPADRE have allowed the PERC Proceedings to continue to evolve and improve. Francette Fey provided much-needed administrative support to the editors. Her assistance was critical to ensuring that the peer review process went smoothly and stayed on schedule.

The peer review process for the PERC Proceedings cannot function without the efforts of those community members who volunteer their time and expertise each year. The editors gratefully acknowledge all of those who participated in the review process:

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Sincerely,

Andrew Pawl
Justyna P. Zwolak
Anne E. Leak

PERC 2025: A PER lens on the International Year of Quantum Science and Technology

Conference Overview

The Physics Education Research Conference has a long tradition of bringing together the PER community to discuss the latest topics, welcome new members, and provide opportunities to learn new research methods and theoretical perspectives, all with the goals of improving the quality and accessibility of physics education. The 2025 PERC is no different. We are discussing contemporary topics, such as education related to quantum technology and generative AI, learning about mixture modeling methods, celebrating the legacy of Joe Redish, supporting PER graduate students and solo researchers, and sharing frameworks for neurodiversity, disability, and how to make our scientific community more caring and humane. The energy of the poster sessions, parallel sessions, and plenary talks made this an exciting conference.

The conference theme was chosen to align with the United Nations declaration of the year 2025 as the International Year of Quantum Science and Technology. The year 2025 is a celebration of 100 years of quantum mechanics with the intent of increasing public awareness of the importance of quantum science and its applications. While quantum concepts, such as quantized energy levels and atomic spectra predate 1925, it was in that year that the mathematical formulation of quantum mechanics was achieved. Heisenberg's matrix approach, Born's rule for calculating probabilities, and the concept of spin all emerged in 1925, and Schrodinger's equation was published in 1926. In the intervening century, quantum ideas have moved from abstract mathematics to practical applications in communication, sensing, and computing. Thought experiments are continually being replaced with real, working experiments and commercialized technologies. The development of quantum computing and other quantum technologies is a funding priority of governments in the United States and other countries and there has been significant private investment as well. However, technologies are developed by people so the growth of quantum technology has been accompanied by a rapid growth in new courses and programs related to quantum computing and other quantum technologies.

While the legacy of quantum mechanics goes back 100 years, we could say that the legacy of quantum-related PER goes back to 1999 with a set of papers presented at the National Association for Research in Science Teaching that was organized by Dean Zollman [1]. In 2000, Chandralekha Singh published a widely cited paper on "Student Understand of Quantum Mechanics" [2]. In 2002, PERC co-chair Beth Thacker was a guest editor for a themed issue of American Journal of Physics about Research on Student Understanding of Quantum Mechanics [3]. The legacy of these early researchers has impacted our plenary speaker, Franziska Greinert, whose PhD advisor was Rainer Müller, an author in that 1999 NARST paper set and the 2002 AJP themed issue [4].

The growth of quantum-related PER is nicely reviewed in the International Handbook of PER chapter on "Research Studies on Learning Quantum Physics" by Michelini and Stefanel [5] and in the 24 articles published in the focused collection of Physical Review PER on "Investigating and Improving Quantum Education through Research" [6]. Over these 26 years, the curriculum has shifted to include a more explicit focus on quantum technology. One consequence of the technological focus is a broader audience for quantum education. While quantum mechanics was typically restricted to advanced physics and chemistry bachelor's students, now many students from engineering and computing disciplines want to learn as well. This has led to new introductory-level quantum computing courses with fewer prerequisites, which plenary speaker Josie Meyer has helped document [7,8]. The focus on quantum education has even entered K-12 education and teacher professional development, which was the focus of plenary speaker, Angela Kelly [9,10].

As increasing numbers of students from many fields take quantum-related courses, there are many open education research questions to which our community can contribute. Plenary speakers Bethany Wilcox and Josie Meyer presented on the development of a standardized conceptual assessment for quantum computing. Angela Kelly emphasized the psychosocial dimensions of education and how recognition, belonging, and self-concept shape interest in learning about quantum topics. Christopher Porter from IBM Quantum Learning addressed how industry and academia each play a role in supporting learning in fast-developing fields. And Franziska Greinert shared about European Union efforts in quantum education as well as a competency framework for quantum-related jobs [11]. Although there was much excellent work presented in the plenaries, parallel sessions, and posters, there is still much work to be done. We hope the 2025 PERC has helped our PER community explore and identify the open questions and opportunities for new education research in quantum science and technology. We also look forward to next year's PERC and the focus on how physics education and PER are being changed by another emerging technology, artificial intelligence.

Organizers

Beth Thacker, Texas Tech University (Co-chair)
Ben Zwickl, Rochester Institute of Technology and University of Oslo (Co-chair)
Amin Bayat Barooni, Georgia State University
Andi Piña, Rochester Institute of Technology
Farai Mazhandu, Colorado School of Mines, University of Witwatersrand
Will Riihiluoma, North Dakota State University

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The PERC 2025 organizers deeply appreciate everyone who worked to make this conference successful. Whether it is leadership and organization from PERLOC, AAPT, and APS, the willingness of plenary speakers to put forth excellent talks, the grassroots organization of parallel sessions, the organizers for the Community Connections events, and the multitude of poster and proceedings submissions, every piece of this contributes to the overall success of the conference. We also appreciate each of the 280+ attendees who came to the conference, engaged openly and respectfully, and contributed to the conference's overall success! A more detailed list of contributors is as follows:

APS and AAPT staff:

Shamera Stewart and the rest of the APS Meetings team
AAPT registration team: Ligette Rogers, Jim Egan and Tommy Olokesusi
Lyle Barbato, ComPADRE Digital Library

D.J. Wagner and the rest of PERLOC

Plenary Speakers:

Angela M. Kelly, Stony Brook University
Bethany R. Wilcox, University of Colorado-Boulder
Chris D. Porter, IBM Quantum Learning
Franziska Greinert, Technical University of Braunschweig
Josephine C. Meyer, University of Colorado-Boulder

Parallel Session Organizers and Moderators:

Alexis Buzzell, Andi Piña, Andrew Elby, Andrew Mason, Ben Zwickl, Beth Thacker, Dina Arch, Eleanor W. Close, Erin Scanlon, Franziska Greinert, Hiba Assi, Idris Malik, J. Caleb Speirs, Karen Nylund-Gibson, Liam McDermott, Marsha Ing, Mason Moenter, Meagan Sundstrom, Prasad Venugopal, Ralf Widenhorn, Raymond Zich, Scott Franklin, Shams El-Adawy, Vanessa Otero, Vashti Sawtelle, W. Brian Lane, Xandria R. Quichocho, Yelissa Lopez, Zhongzhou Chen

Community Connection Session Hosts:

Alejandro de la Puente, Alexis Buzzell, Andi Piña, Cami Monsalve, Carissa Myers, Frank (Erin) Dachille, Idris Malik, Susan White, Trevor Owens, Zhongzhou Chen

PERC Proceedings Editors and Staff:

Andrew Pawl (2023-25), Justyna Zwolack (2024-26), Anne Leak (2025-27)

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PERC 2025 Schedule at a Glance

EDT	Wednesday, August 6, 2025
2:00pm	**PERC Kickoff:** *PERC Organizing Committee* **Quantum computing assessment: new challenges for the interdisciplinary era** *Plenary Speakers: Bethany Wilcox and Josie Meyer* **Bridging the gap: an industry perspective on quantum education** *Plenary Speaker: Chris Porter*
3:45pm	Poster Session Setup and Coffee Break
4:15pm	**Parallel Sessions A** **Solo PER: Networking and Collaboration for Individual Researchers** *Round Table Discussion Leaders: A. J. Mason and R. Zich* **Disability and Neurodivergent Demographics in Physics Education Research – Creating a Framework** *Critical Conversation Hosts: L. McDermott, D. McPadden, M. Moenter, and E. Scanlon* **Quantum Physics Education Research Poster Symposium** *Poster Symposium Moderators: A. Buzzell, Andi Piña; Presenters: J. Bass, E. Burkholder, B. Gierus, M. Griston, D. Luo, N. Pradeep, D. Serrano, B. Thacker, and M. L. Whiting* **Physics Education Research in a Time of Socio Political Turmoil** *Critical Conversation Moderators: H. Assi, S. Franklin, V. Sawtelle, and P. Venugopal*
5:45pm	Dinner on your own
7:30pm	Poster Session A (7:30-8:10pm). Poster Session B (8:20-9:00pm).

EDT	Thursday, August 7, 2025
8:00am	**Parallel Sessions B** **Gloria Anzaldua's Work coming into PER** *Talk Symposium Moderator: V. Sawtelle; Presenters: P. Chung, A. E. Leak, C. Monsalve Avendaño, I. Rodriguez, V. Sawtelle, C. Vaca, and T. G. Young* **Researching and Interrogating Grading Practices in Physics** *Poster Symposium Moderators: W. B. Lane, J. C. Speirs; Presenters: J. B. Buncher, W. B. Lane, T. K. Lê, J. C. Speirs, and M. Vasquez-Vega* **Exploring heterogeneity in our samples: An introductory workshop on Mixture Modeling** *Workshop Facilitators: D. Arch, M. Ing, M. Sundstrom, and K. Nylund-Gibson* **Celebrating Joe Redish's Scholarly Legacy** *Custom Format Host: A. Elby; Presenters: B. Geller, and R. Russ*

	Designing the future of quantum-related PER *Workshop Facilitators: A. Piña, B. Thacker, and B. Zwickl*
9:40am	Poster Session C (9:40-10:20am).
10:30am	**Quantum Technology Education: Projects, Research, and a Reference Framework for Europe and Beyond** *Plenary Speaker: Franziska Greinert*
11:25am	**Community Connections** **Quantum Physics Education Research, Resources, and Community** - *Hosts: A. Buzzell and A. Piña* **A Gathering of Students hosted by PERCoGS** *Host: I. Malik and PERCoGS* **Generative Conversations: Supporting Research Through Community** *Hosts: F. Dachille, C. Monsalve, and C. Myers* **Challenges and Opportunities for Teaching Physics in the Era of Generative Artificial Intelligence** *Host: Z. Chen* **The Society of Physics Students and PER Collaborations** *Host: A. de la Puente, T. Owens, and S. White*
12:25pm	Lunch on your own
1:50pm	**Psychosocial considerations in precollege learning of quantum information science and technology** *Plenary Speaker: Angela Kelly*
2:35pm	Coffee Break and Poster Take Down
3:00pm	**Parallel Sessions C** **The Future of Quantum Workforce: Who's Being Trained? Who's Being Hired? and What's Missing?** *Critical Conversation Leaders: V. Otero; Facilitators: F.Greinert, Y. Lopez, and B. Zwickl* **Transforming Teaching and Research with AI/GenAI** *Poster Symposium Presenters: Z. Chen, G. Kortemeyer, J. Nöhl, G. Polverini, A. Sirnoorkar, R. Widenhorn, and N. Young* **What's Next? A Panel on Non-Academic Career Paths in PER** *Panel Moderators: I. Malik, Andi Piña; Panelists: A. Hodari, C. Porter, and A. Roti Roti* **Whither PER II? Future Directions for PER** *Workshop Moderators: A. J. Mason, and R. Zich* **Using the Critical Physics Identity framework to identify ways to support diverse students** *Workshop Facilitators: E. W. Close, and X. R. Quichocho*
4:30pm	**End of PERC**

Introduction

Papers published in the 2025 Physics Education Research Conference Proceedings consists of 72 peer-reviewed papers and two plenary papers.

The peer-reviewed papers are written products of any presentation including the juried talks, parallel sessions, and poster sessions. Each paper undergoes a rigorous peer review process in order to be published in the Proceedings. This year saw 87 submitted manuscripts, of which the aforementioned 72 papers were accepted for final publication.

The readership of the Physics Education Research Conference Proceedings includes faculty, post-doctoral associates, and graduate and undergraduate students in physics education; scholars in other discipline-based science education or closely related fields, such as cognitive science; practitioners in physics or other sciences, such as teaching faculty at undergraduate and graduate levels, and high school physics teachers.